DISCOVERY

4P

THE PROGRESS OF SCIENCE

POLIOMYELITIS VACCINE: WHAT IS ITS FUTURE?
W. L. M. Perry, *M.D.*

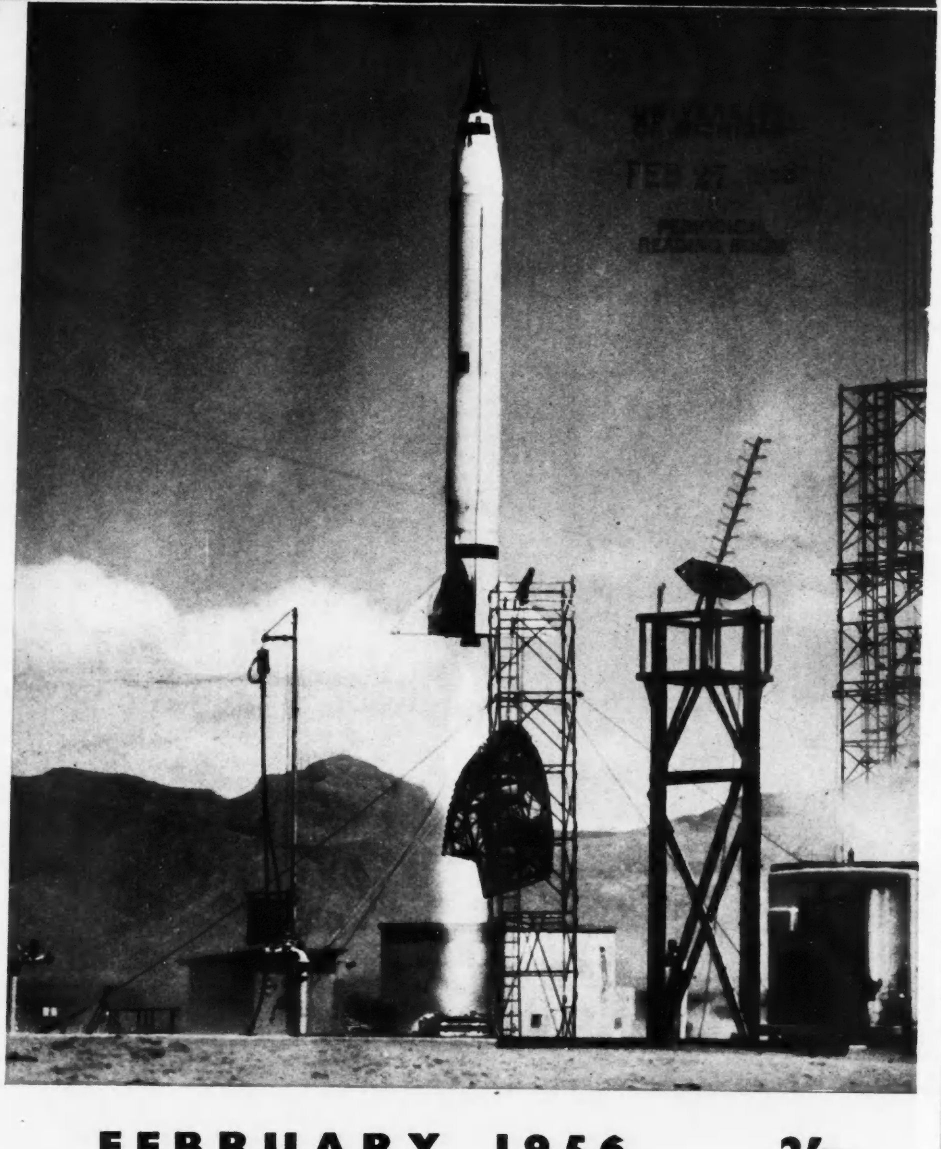
PHOTOPERIODISM AND ITS PRACTICAL IMPORTANCE
P. F. Wareing
B.Sc., Ph.D.

THE HEAT PUMP AND ITS APPLICATIONS
M. V. Griffith
B.Sc., F.Inst.P.

ROCKETS IN THE UPPER ATMOSPHERE
R. L. F. Boyd, *Ph.D.*

THE MOST ACCURATE CUBE IN THE WORLD
A. G. Thomson

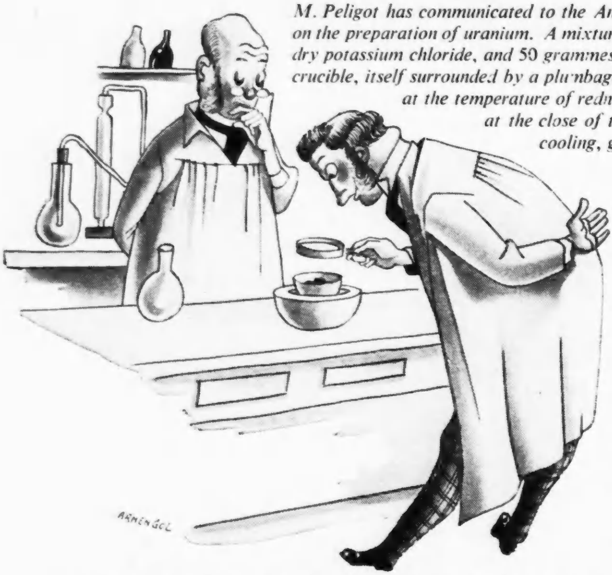
THE SEA AS A CHEMICAL STORE
J. Gordon Cook
Ph.D., F.R.I.C.



The Viking research rocket which reached an altitude of 158 miles on May 24, 1954.

FEBRUARY 1956 **2/-**

M. Peligot finds uranium



M. Peligot has communicated to the Annales de Chimie et Physique (xvii, 363) a short note on the preparation of uranium. A mixture of 75 grammes of uranous chloride, 150 grammes of dry potassium chloride, and 50 grammes of sodium in fragments is introduced into a porcelain crucible, itself surrounded by a plumbago crucible. The reaction is effected in a wind furnace at the temperature of redness; but the heat must be increased for a short time at the close of the operation. In the black slag may be found, after cooling, globules of fused uranium.

The new method of producing uranium was announced in the first issue of Nature in 1869. Monsieur Peligot, who twenty-eight years before had first isolated the metal, discovered by Klaproth in 1789, was opening the door a little more widely to the possibility of an Atomic Age a century later.

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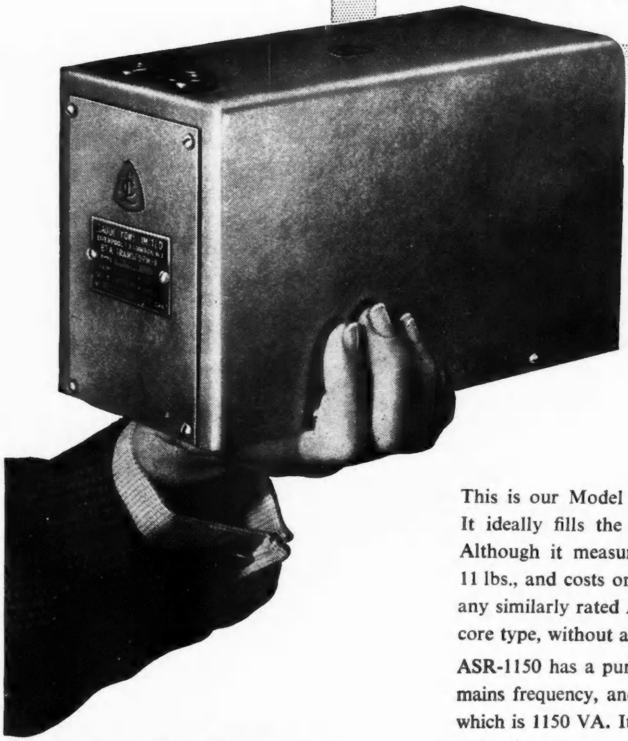

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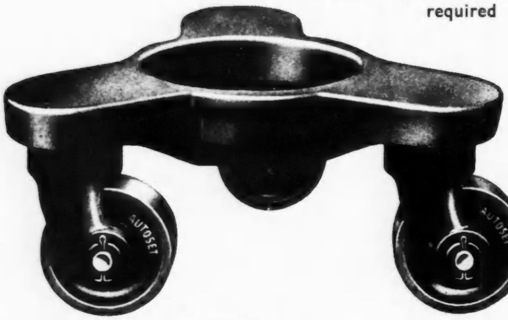

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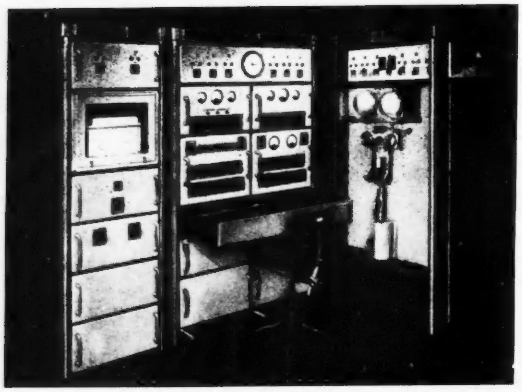

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115	0·70	0·37	**11·2**	35·8	10·3	19·0	15·0	6·2	0·81	0·65
117	0·56	0·16	0·47	3·2	**69·9**	14·0	2·7	2·9	5·7	0·44
118	0·22	<0·04	<0·04	0·25	0·93	**94·1**	2·95	1·36	0·08	0·10
119	0·33	0·11	<0·04	0·49	0·72	18·5	**71·7**	7·3	0·67	0·22
122	0·20	0·34	0·34	2·1	8·7	5·1	2·6	3·4	**75·3**	1·95

The table illustrates the application of the MS2 to Isotope assay work. Samples of stannic chloride enriched by electro-magnetic separation, were analysed and compared with a normal sample. The figures in bold type are the final amounts of the particular isotopes in which the samples were enriched.

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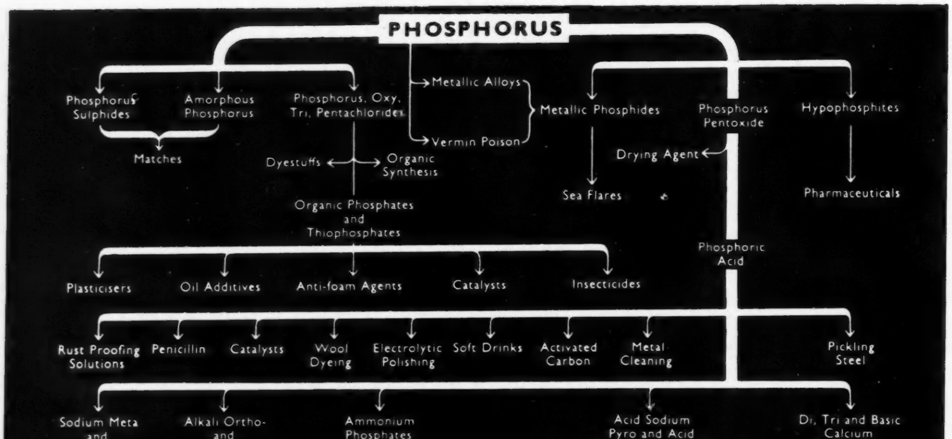

Chart showing Phosphorus Derivatives manufactured by ALBRIGHT & WILSON LTD 49 PARK LANE · LONDON · W.1

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THE PROGRESS OF SCIENCE

RUSSIA'S OUTPUT OF SCIENTISTS AND TECHNOLOGISTS

Among the slogans with which Stalin in 1929 launched the first Soviet Five-Year Plan, was the cryptic phrase "Cadres decide everything". The term "cadre" was taken over from the strictly military sense and applied to the army of professional workers who were to be the driving force of Soviet industrialisation. Sir Winston Churchill in his notable Woodford speech has now sounded a warning that this army has been built, that Britain lags behind in technical education and the matter "needs the immediate attention of the Government".

His speech followed the issue in America of "Soviet Professional Manpower". This research study by Nicholas DeWitt has been published by the National Science Foundation in co-operation with the National Academy of Sciences and National Research Council and covers the Soviet educational system and the supply and distribution of professional manpower. The results can be summarised quite simply.

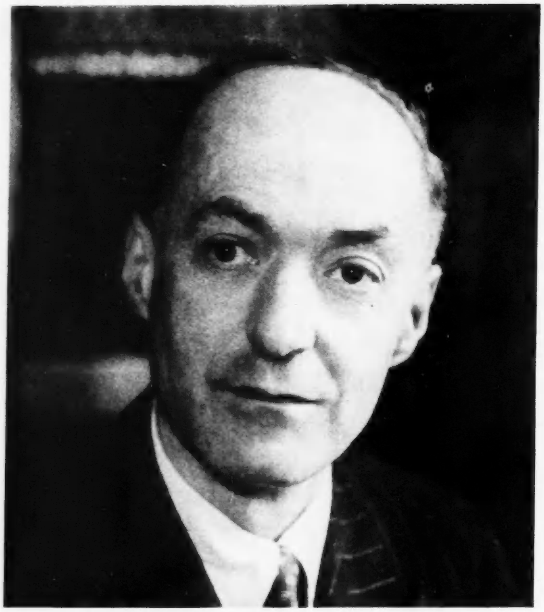
The Soviet Union is turning out twice as many technical specialists in certain fields as the United States. Between 1928 and 1954 the Soviet Union produced 682,000 engineering graduates, against 480,000 in the United States over the same period. Agricultural graduates in the Soviet Union numbered 244,000 against 133,000 in the U.S.; Soviet graduates in medicine outnumbered American two to one, 320,000 against 148,000.

Lord Simon of Wythenshawe had earlier given figures which show Britain's comparative position in this context. For every technologist we produce, the U.S.A. produces five and the Soviet Union eight. This is the position today in spite of the doubling of numbers since the Barlow committee reported on professional manpower in 1946. Recent discussion has acknowledged this progress but queried its adequacy. The chairman of English Electric, Sir George Nelson, probably put his finger on the key point when he said recently:

> "It is still doubtful, however, if parents are giving sufficient attention to the national importance of technology and to the opportunities for careers of high professional standing. It is important that parents and students should realise that men trained to design and produce great engineering projects, that constitute the modern wonders of the world and contribute so much to mankind, are as well educated and cultured as men who have learnt to read Greek and Latin."

The DeWitt book proves that the Soviet advances are due in great measure to the social climate. The people in demand are the engineers, agricultural specialists and teachers. The teaching institutions set out to produce them. The Soviet universities produce only a small number of graduates, perhaps 10% of the total, from thirty-three universities ranging in size from the 20,000 students of Moscow and Leningrad down to about 3000. The six faculties commonly found are philology, history, geography, biology and chemistry and applied subjects such as engineering and medicine are almost unrepresented. They are well catered for, on the other hand, in over 800 institutes; the size of the student body in these ranges from a thousand or so, up to about 8000 in the largest engineering institutes. The courses of study lasts 4–6 years and produce a graduate comparable with those of universities abroad. The course work may seem to be excessive: Soviet mechanical engineering training requires 2000 hours more instruction than the first degree (B.S.) of the Massachusetts Institute of Technology in the same subject. In chemical engineering, the Soviet course demands 4700 hours of instruction against 3200 at MIT.

DeWitt compares these examples and sums up: "It appears that engineering training in the Soviet Union diverges from our own when technological specialisation enters the scene. General scientific and general



Sir Cyril Hinshelwood, who has succeeded Lord Adrian as President of the Royal Society.

engineering training are quite comparable, despite the differences in time inputs already noted. Foreign-language training (primarily in German and English), which is considered one of the general science subjects because such instruction concentrates on translating and reading in foreign scientific/technical literature, is stressed in the Soviet case, while it plays a relatively minor role in our engineering education. We devote from 12 to 15% of instruction time to general literal arts education, while the Soviet programmes devote none, and what they call social science subjects are nothing but political indoctrination. Soviet engineering training continues along formal lines of instruction into narrow technological specialisation, while our B.S. engineering graduates acquire these technological skills through proper employment or through special supplementary training programmes offered by various industrial corporations."

For the student of education, the details of the courses are of great interest, particularly the 4–6 months' diploma project at the end, but only a few salient facts can be picked out here to show what the end-products are. The main groups of Soviet engineering students in 1950 were:

Aeronautical engineering	3–5%
Chemical engineering	12–14%
Civil engineering	10–12%
Electrical engineering	12–14%
Economics and management	8–10%
Mechanical engineering	28–32%
Mining and metallurgy	12–14%
Other	6–8%

Out of 2 million professional graduates in one year, about 42% were trained for, and employed in, education. The rest went to agriculture (9%), engineering and general industry (27%), medical work (16%) with only 6% to sociological work. Although these 2 million compare as a total with the 5½ million graduates in a year of the United States, the latter could turn out only 8% as engineers.

One further point is needed to complete the picture. This phalanx of Soviet professional engineers has the support of millions of technicians or semi-professionals. The Soviet aim is to provide three technicians for each professional graduate, but it has not been possible to exceed a ratio of 1·7 to one. The whole lot add up to an army which, strategically appraised, will carry out Mr. Bulganin's promise—to conquer the world by economic means.

Perhaps the authority of Sir Winston Churchill will demand attention to our relative position in technical education. His warning will drive politicians and university committee members to DeWitt's book, but who can take the lead in making the changes which, to be successful, must raise the whole standing of technology in this country?

SCIENTIFIC WRITING AND SCIENTIFIC BEST-SELLERS

The two related items entitled "Scientific 'Illiteracy'" and "Scientific Best-sellers" in our December issue have produced a considerable number of letters, some of which we print elsewhere in this number.

More than one reader drew our attention to the leader in the *Journal of the Royal Institute of Chemistry* which appeared a few weeks earlier and discussed the importance of good scientific writing. This stated that the Royal Institute of Chemistry has cause to worry, and the Institute's council is perturbed by the poor quality of essays entered for the Frankland Prize and by the reports of the Examinations Board "on the low standard of written work produced by most candidates" for the ARIC. Some people are inclined to put all the blame for the prevalence of bad writing upon the schools. We do not agree with this approach, and the writer responsible for the RIC journal's leader evidently does not agree either, as this comment shows:

> A student automatically adopts the style of his teachers and of those who write the papers and textbooks he reads; if these authors are not good expositors and good writers, the student who grows up with them may never realise his own shortcomings, though he is certain to possess them.

If the standard of scientific writing is to be raised, the universities will need to make some contribution to the solution of this problem. That seems to be the logical conclusion to be drawn from a consideration of all the facts.

Prof. E. N. da C. Andrade sent us a reprint of the lecture on "The presentation of scientific information" which he delivered before the Royal Society Information Conference (June 1948). The full paper is well worth reading (it can be found in the *Proceedings of*

the Royal Society, A, 1949, vol. 197) for Prof. Andrade is a first-class writer and expositor, and here we can do no more than quote one passage from it:

> Many who realise how much some of the papers written today, especially as first presented, are wanting in clarity and conciseness, to say nothing of elegance, have suggested that our young research workers should be made to take courses in English in the English departments of our universities. I scarcely think that this is the way to go about it. Some of the worst English that I have read has been written by D.Litt.s . . . Rather read to the young man an account of a piece of work as written by a master and then let him write his own account and compare it subsequently with the original. Personally I feel that a wrong ideal is often the cause of much of the trouble. The young man wants a long paper suspecting, in many cases rightly, that when it comes to applying for a higher post his achievement will be estimated by the number of pages that he has produced. He wants one that looks as formidable as possible judging, in many cases rightly, that the senior who looks at it will think more highly of him if it is full of forbidding phrases and long words, especially if they are new words, such as, let us say, diclastically disintegrated to mean "cut into two bits". If it were conveyed to him that simple expression is in itself desirable, that every new word needs careful justification, that scientific jargon is not in itself scientific advance there would, I think, be an improvement. Personally, when a young man brings me a mass of verbiage I ask him, gently, what exactly he means, and when, as usually happens, after much questioning he has reached a perfectly simple form of words I say "Then why not say so?" I think that it is as simple as that. . . . All that I ask is a freedom from unnecessary clumsiness and obscurity. I do not ask that scientific papers shall be pleasant to read, only that they shall not be repugnant.

* * *

Several publishers have followed up the second "Progress of Science" item and provided us with interesting figures for their scientific best-sellers. In December we mentioned Sir James Jeans's *The Mysterious Universe*, of which Cambridge University Press sold 240,574. The most successful British book on astronomy produced since the war is probably Hoyle's *Nature of the Universe*; its publisher, Basil Blackwell, states that 110,000 copies have been sold.

Another high figure has been achieved by Konrad Lorenz's book *King Solomon's Ring*. Originally published by Methuen, it has appeared in several book club editions, and the total sales have exceeded 300,000. To take a very different type of book published by the same house, we find that Einstein's *Relativity: The Special and the General Theory* (probably the most easily comprehensible exposition of relativity that he wrote) sold about 32,000 in its English edition. Another interesting figure from Methuen is the figure for McDougall's *Social Psychology*—76,000 in its English edition.

The Royal Institution Christmas Lectures, a number of which have been published in book form by G. Bell & Sons Ltd., have sold well. Good examples are the two volumes by Sir William Bragg—*The World of Sound* (22,300) and *Concerning the Nature of Things* (21,700). Prof. Andrade's RI lectures published under the title of *Engines* sold to the tune of 17,000 copies.

Heinemann's educational department provided the following figures: Dr. Sherwood Taylor's *The World of Science*, 46,000; Hoyle's *Frontiers of Astronomy*, 13,000 copies since publication last summer. Scientific textbooks for school use can sell very well: an example is Heinemann's *School Certificate Chemistry* by Holderness and Lambert, of which 190,000 copies have been sold. We should certainly be pleased to publish figures from other publishers for their best-selling textbooks; the only proviso we would make is that the books should be concerned with scientific subjects *other than mathematics*.

Sir Raymond Priestley, who is President of the British Association for 1956. At the ceremony at Burlington House on January 6 when he was installed in office by the retiring president Sir Robert Robinson, he appealed to speakers at the next meeting (to be held in Sheffield on August 29–September 5) to endeavour to make their papers intelligible to ordinary people. Sir Raymond, a geologist by training, recently took over temporary direction of the Falkland Islands Dependencies Scientific Bureau during the absence of Dr. V. E. Fuchs.

It needs to be realised that a great many important scientific books can never enter the best-selling class for the very good reason that they are specialised works dealing with a field in which research is proceeding rapidly. Because they are designed to be up-to-date monographs, they are inevitably superseded in a comparatively short time. Their life is bound to be short and their sales are accordingly limited. In all such cases the sales figure bears no direct relationship to the importance of the function the book fulfils. It is because they concentrate on this class of book that several of the outstanding scientific publishers are not mentioned in this note.

SITUATION VACANT: THE DIRECTORSHIP OF THE N.P.L.

Many months have been spent searching for a scientist who is willing, and at the same time of the high calibre required, to direct the activities of the National Physical

Laboratory. The search proved unavailing in 1955, and when Sir Edward Bullard's resignation from the directorship took effect on December 31 all that the DSIR could say about his successor was "The appointment of a successor will be announced in due course." The Press statement issued by the DSIR explained that there will now be an interregnum with an acting director in charge of this very important laboratory.

Does the failure to find a new director reflect a shortage of scientists with the capacity to lead? Or is it that the salary offered does not match the importance of the post? There is abundant room for discussion on both points. But when considering them, it is essential to take into account the very nature of the laboratory, which has become over the years a great sprawling colossus with heavy administrative responsibilities. Some of the difficulties arise from the fact that the Civil Service straightjacket imposes on scientists at this level restrictions and limitations which even the hope of a knighthood will not outweigh.

Sir Edward, who at forty-eight has left to take up a newly-created fellowship in geophysics at Cambridge, will be replaced temporarily by an acting director, Dr. R. L. Rose, director of radio research in the Department of Scientific and Industrial Research, who is sixty-one.

The National Physical Laboratory is one of the largest and most important scientific institutions in Britain. It is the biggest single unit in the DSIR, spending £830,000 a year and employing a thousand graduates. It deals with problems as diverse as the shape of supersonic aircraft, new liners and bridges, the circuitry of electronic computers and the formulation of new physical standards. Its staff have been responsible for the most accurate determination of the speed of light, a matter of fundamental importance in many fields. It undertakes a certain amount of research under contract, especially for defence departments, and it also carries on a host of routine tasks that even include the certification of thermometers.

The post has not been advertised and the search for a director, at least in the initial stages, is always conducted on a very informal basis. Many people have been approached in this way. Candidates face the fact that the financial rewards of the post compare unfavourably with those of comparable responsibility in industry. It is understood that when Sir Edward Bullard was first approached in 1950 he was offered £2250 and turned it down at once. He eventually accepted £3250. Many people of the requisite seniority consider this inadequate, all the more so because there is no official entertainment provision in spite of the fact that commitments in this respect can be extremely heavy if the job is performed in the spirit that it ought to be. Other possible candidates have regretted the lack of a personal laboratory for the director. He would have one in a university.

INVESTIGATING NOISE

The march of science and technology has made the world of science a much noisier place to live in, and the rather rare developments that make for noise abatement are eclipsed by the technical advances which have added to the burden of everyday noise.

There are, of course, some scientists working on problems of noise. In the aviation field, for example, some progress has been made and one or two promising methods for reducing the noise made by jet engines are beginning to emerge. But altogether the amount of research that has been done that is likely to lead to a reduction of the strains which noise imposes on 20th-century man is relatively small. It is true that some of the knowledge that could be applied to the general relief of everybody is not being applied very vigorously. One of the troubles is that those of our legislators, the members of Parliament, for example, who are interested in the noise problem, have little or no contact with the technical experts working in this field. In Parliament one of the men who has urged the case for less noise most persistently is Lord Lucas, and his arguments have been widely reported. In spite of this Lord Lucas states in a letter to the editor that "I do not know of any scientists who are giving any thought whatsoever to the problems. There may be some but I have not come across them." This indicates a serious lack of liaison between the parliamentarians and the scientists: this gap could be filled if the Parliamentary and Scientific Committee will invite some of the noise experts to talk to them.

Noise was the subject of an important debate in the House of Commons recently, and a Government spokesman took the opportunity of indicating what scientific work on problems of noise is in progress. The debate took place on the motion of Sir Lionel Heald, M.P. for Chertsey, "That this House notes with concern the detrimental effect of noise and vibration on the health, wellbeing and efficiency of the nation; and urges Her Majesty's Government to give careful attention to the importance of research and education in this field, and to the need for more effective measures for the protection of the public."

Sir Lionel's view was that scientists and medical men have collected much relevant information, but that this is not utilised in the way it should be. He mentioned a number of published articles, his first reference being to Dr. Pilpel's article on the reduction of aircraft noise which we published nearly a year ago (DISCOVERY, March 1955, pp. 102–5). He regarded the regulations dealing with excessive noise from motor-cars and motorcycles as "almost completely useless", and from the fact that separate records of silencer offences are not kept he drew the conclusion that the Government attaches no great importance to the problem. He said Britain does little about the noise connected with factories and manufacturing processes that affects not only the factory workers but also those who live nearby. Sir Lionel hoped that the Government would follow up the work being done in other countries, particularly the U.S.A. (Sir Lionel quoted a figure of about 500 for the number of U.S. scientists engaged on noise problems, whereas the figure for Britain he put at not more than twenty.) At least three things have to be organised if noise is to be minimised: there must be education and there must

be legislation—but first there should be research and investigation, and Sir Lionel stressed that the research effort in Britain needs to be stepped up and given more Government support.

Another M.P., Mr. Ronald Bell, thought that the money being spent on finding ways of reducing jet-engine noise was insufficient. The problem is, of course, a difficult one since the noise from a jet increases as the eighth power of the speed of the gas leaving the jet. (That fact, discovered by Prof. M. J. Lighthill of Manchester University, was dealt with in the DISCOVERY article referred to above.) Mr. Bell considered one or two technical trends which promise to make British cities noisier rather than the reverse; for example, he said we should develop electric traction instead of replacing trolley-buses with diesel buses—which he said was encouraging the noisiest and smelliest forms of locomotion.

Several M.Ps. used the occasion to plead the special cases of their constituencies that include aerodromes, and a great deal was said about the big and serious problem of aircraft noise. But no one held out any high hopes of a satisfactory solution being found in the near future. To some extent one has to accept that more noise is bound to accompany progress along certain lines of technical advance. This was well expressed by Mr. R. Gresham Cooke, who said:

> To sum up, I would say that noise is inseparable from movement. The greater the mass moved and the greater the speed, the greater the volume of sound. Much has been done to deaden the noise of the internal combustion engine on the road. What science and industrial effort must now do is to smooth out the peaks which are so objectionable to the human ear, and, in the field of aircraft, to find solutions which, broadly, have already been found for the internal combustion engine on the road.

This view does, however, rather oversimplify the problem: can it be assumed that human beings could comfortably tolerate the residual noise that Mr. Cooke envisaged? Not very much work has been done on the effects of noise on human beings, and little is known about the maximum noise level that human beings can tolerate without suffering ill effects. The kind of investigation that is being made is concerned with extreme values—the kind of noise levels that cause physical damage to the ear. At much lower levels than that factory workers find that their efficiency is considerably impaired. The Medical Research Council has only recently started to investigate the general psychological effects of noise in this context, but this research is restricted to noise in "particular noisy occupations".

The Government reply came from Sir Hugh Lucas-Tooth, Under-secretary for the Home Office. He was very diplomatic about road vehicles. The manufacturers have agreed with the Ministry of Transport to keep voluntarily to "reasonable levels of maximum noise", and apparently if complaints are made about a particular make of car then the Ministry takes the matter up with the maker. The problem of aircraft noise (which he described as "intractable") is being investigated in a number of places. He said that basic research into reduction of this kind of noise is going on at the College of Aeronautics, the National Physical Laboratory and the Universities of Southampton and Manchester. This work is co-ordinated by the Ministry of Supply, which is concerned with research into propeller noise as well as that of jet engines. As an example of what is being done to reduce the spread of noise from grounded planes that are warming up or being tested, he quoted the 30-foot bank of earth that is being put up at London Airport to provide a pen for the Britannia.

The transmission of noise inside buildings is one field that has received considerable attention. The Building Research Station has studied this matter thoroughly and their results are available to all builders and architects who are interested in achieving high standards of sound insulation. This same laboratory is continuing this work in the hope of reducing the expense of such insulation. The architects of the Ministries of Health and Education are paying special attention to the noise problems of hospitals and schools.

At the National Physical Laboratory an important series of investigations has just been completed which helps to put the relationship between the *intensity* and *loudness* of noises on a firm scientific basis. This work has been directed by Mr. D. W. Robinson.

As to noise in factories, the official spokesman said the Government supported the recommendation of the International Labour Conference (1953) calling upon employers to take measures to eliminate as far as possible noise constituting a danger to the health of workers. He said that legislation in the present state of knowledge is impossible, but H.M. Inspectors of Factories can give encouragement in the right direction. (Incidentally it is to be hoped that British experts concerned with industrial noise are in close touch with the Acoustics Group in Canada's National Research Council's Division of Applied Physics. This group, under the direction of Dr. G. Thiessen, is doing valuable work and has solved several big problems in the field of industrial noise.)

It was clear from this debate that plenty of M.Ps. are prepared to campaign for noise abatement. It was equally clear that the solution of only a few noise problems is known, and then not widely enough. Finally, there are many problems that have not been tackled at all, and others that require a bigger research effort than is at present devoted to them. The scientists working in this field might very profitably review what is being done to find out where there are gaps in our knowledge. At this stage public opinion would certainly support any proposals from the scientific world as to new lines of research that might lead to the solution of particular noise problems.

POLIOMYELITIS VACCINE: WHAT IS ITS FUTURE?

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The author of this article was one of the experts who attended the recent W.H.O. conference in Stockholm which reviewed the results so far achieved by the use of polio vaccine. In this article he refers to the conclusions which the conference reached, and discusses some of the points that have to be considered by health authorities when deciding on their policy with regard to polio vaccination. Since this article was written the Minister of Health has announced that large-scale vaccination of British children with modified Salk vaccine will begin in May.

A few weeks ago, the World Health Organisation called together in Stockholm a group of scientists from nine countries to study and review the evidence about vaccination against poliomyelitis which has been accumulated during the past two years. As a result of its review, the group recommended that, provided a number of safeguards were introduced, countries with a high incidence of paralytic poliomyelitis should plan to bring vaccination into routine use at an early date.

This recommendation can only be interpreted as a statement of faith in the safety and protective power of formalin-treated poliomyelitis vaccine, and is bound to affect the policy of health departments throughout the world. It is doubly important because of the very confused picture that emerged during 1955: a picture that varied in colour from wild enthusiasm, through foreboding, to rational and limited optimism. It is now essential that the effects of the enthusiasm and of the gloom be minimised, for only thus can the present position be fairly assessed. It is in this light that the Stockholm review must be read.

In this article I have tried to sketch the background to the 1955 picture, to draw in more detail the events of 1955 itself, and to end with a review of the implications, for Britain, of the rational limited optimism expressed at Stockholm.

THE BACKGROUND

There can have been few therapeutic substances which have been developed, tested and brought into widespread use within such a short space of time as poliomyelitis vaccine. The technique of growing monkey kidney cells in tissue culture as the medium for the cultivation of the virus was developed by Enders, Weller and Robbins only in 1949. Within four years, Salk had adapted the technique to the purpose of producing polio virus suspensions on a large scale and had worked out methods of inactivation of the suspension which he claimed were reliable and effective.* He had also tested the inactivated suspension (the vaccine) in small numbers of children without untoward results. Thus in 1953, the National Foundation for Infantile Paralysis of the U.S.A. was convinced that there was now available a vaccine against poliomyelitis which deserved a clinical trial of its effectiveness.

Thereafter, events moved even more rapidly. Arrangements were made by the National Foundation for Infantile Paralysis for the manufacture in Canada and the U.S.A. of large quantities of the vaccine, and for the clinical trial of the material in children in the first three grades of school, i.e. children aged 6–9 in September 1953. (Actually the age group was approximately 7–10 by the time the trial was held in the spring of 1954.) The trial was held in two parts. In some areas the available children were divided into two strictly comparable groups, of which one received vaccine injections while the other received injections of a sterile fluid coloured so as to resemble the vaccine but having no active ingredients. Each of these groups comprised some 200,000 children, and this part of the trial conformed to the most rigid biometrical requirements. The other part of the trial was less well controlled; the vaccine was administered in other areas to all children in the second grade of school, and the uninoculated children in the first and third grades of school were used as the controls. In this part of the trial, nearly a quarter of a million more children were vaccinated.

This vast trial was carried out in the spring of 1954, and a team of experts led by Dr. Thomas Francis carried out, during the following twelve months, a detailed evaluation of the results. Their report was published on April 12, 1955. In summary, this indicated that the vaccine had been safe in that it had been given to over 400,000 children without apparent mishap, and that it had been effective in that it had prevented paralytic poliomyelitis in some 60–90% of the children who received it. The date chosen for the announcement of the result of the trial, namely April 12, 1955, was the tenth anniversary of the death of Franklin D. Roosevelt who had himself been a victim of paralytic poliomyelitis. The choice of date and the manner of making the announcement were perhaps unfortunate in that they courted publicity. Consequently, the results of the trial were made available to Press and public before there had been any opportunity for responsible health authorities to study the details of the report.

Mature opinion about the report concurs with that of its authors insofar as the controlled part of the trial is concerned, namely, that there is evidence that the vaccine had at least 60% protective power in that group; but scepticism has continually been expressed about the validity of the rest of the study. It is also generally agreed that the vaccine, as used in the trial, appeared to be safe.

* Further details of this technique were given in our Progress of Science note entitled "The American Polio Vaccine", 1955, vol. 16, pp. 223–5.

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THE PREPARATION OF POLIO VACCINE

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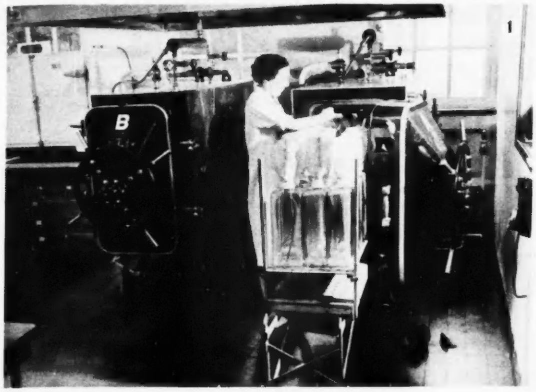

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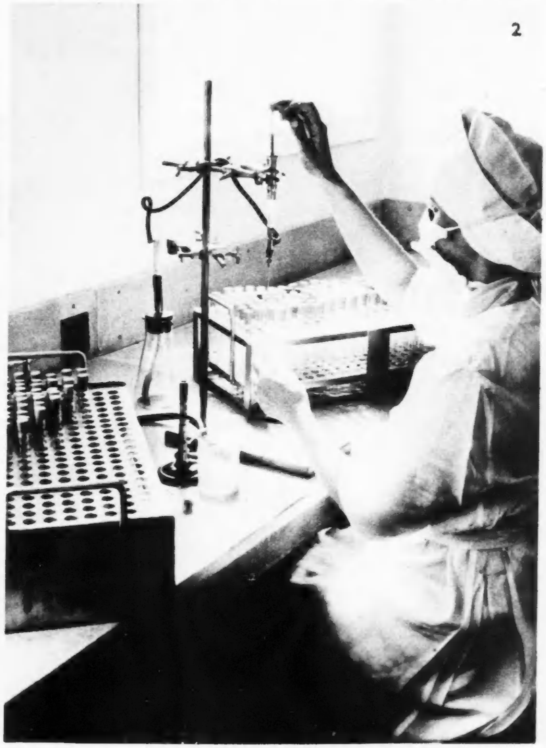

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Two British firms, Glaxo Laboratories Ltd. and Burroughs Wellcome & Co., are making polio vaccine. These photographs were taken at the Glaxo Virus Research Laboratories at Stoke Poges, Bucks.
1. Sterilisation of the culture bottles used for the large-scale propagation of polio virus. **2.** Replacement of old medium with fresh medium in test-tube tissue cultures. **3.** General view of the Virus Assay Section where the potency of virus fluids is checked. **4.** Incubation of test-tube cultures for use in general assay procedures. **5.** Virus produced in the culture bottles shown in Fig. 1 is bulked and treated with formalin. A quantity of treated virus is seen going into the incubator for inactivation.

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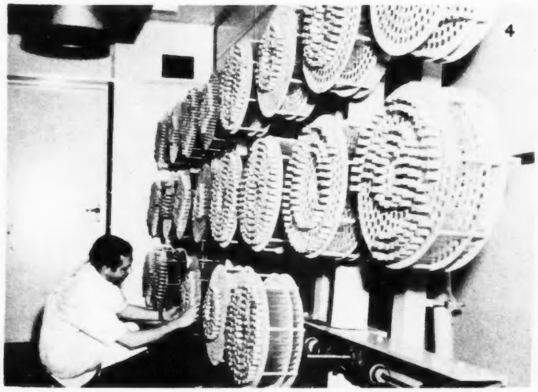

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THE 1955 STORY

There had, however, been no real opportunity for mature reflection before the large-scale vaccination campaigns were launched in the spring of 1955. The National Foundation for Infantile Paralysis announced that it would provide vaccine, free of charge, for all children in the first and second grades of school in the U.S.A.; in Canada and Denmark vaccination of similar age groups was also ready to start; and in many other countries preparations were being made for vaccine production and use.

In the U.S.A., six firms were licensed to manufacture vaccine. The vaccine was tested in the same way as in 1954, except for this difference: in most cases, only the manufacturer carried out the tests, whereas in the previous year arrangements had been made to carry out the tests *in triplicate* on all batches of vaccine. The stricter arrangement was impracticable with the much larger amounts of vaccine now called for. It was against this background that mass vaccination began on April 13, 1955. Only two weeks later, on April 26, the first five cases of poliomyelitis following injection of vaccine made by the Cutter laboratories were reported. As the numbers of such cases increased, the mass vaccination campaign was temporarily suspended on May 8, by which time some 5 million children had received one dose of vaccine.

The accident after the use of the Cutter vaccine, coming as it did so soon after the announcement of the success of the 1954 field trial, threw health authorities throughout the world into a state of confusion. They did not know the real cause of the accidents and in many countries, including Britain, all vaccination programmes were cancelled. On June 10, the U.S. Government issued a technical report in which the situation was reviewed. It was concluded in this report that the tests carried out on the vaccine had been insufficiently stringent and, indeed, live virus has since been isolated from some of the batches of Cutter vaccine concerned in the accident. It was pointed out that the stringency had been less for smaller batches than for larger ones, since the sample of vaccine tested had been related to the size of the batch. New testing requirements had consequently been issued on May 26. The report also summarised the extent of the accidents with Cutter vaccine and a more detailed report has recently (November 15, 1955) been issued on this problem. It now appears that 204 cases of poliomyelitis, with 11 deaths, may be attributed to infection produced by this vaccine. Of these, 79 were in vaccinated children, 105 were in members of the family of vaccinated children and 20 were in close contacts outside the families. Most of the cases were associated with two particular batches of vaccine. Vaccine from the other manufacturers was not implicated in any accident except for one possible series of five cases associated with vaccine from one other manufacturer.

The vaccination programme was started again and has since proceeded without interruption. The pace has, however, been slower, since all vaccine has been subjected to a series of tests which are not only more stringent and more time-consuming, but which may also result in the rejection of a higher proportion of batches as unacceptable. Thus the supply of vaccine has been smaller than expected. Nevertheless, well over 10 million children have been vaccinated in the U.S.A. and, despite an extremely careful watch for cases of poliomyelitis resulting from vaccination, no further accident has occurred. Meanwhile, in Canada and Denmark, mass vaccination had also gone ahead and in each country more than 800,000 children had been vaccinated, without any apparent trouble.

Thus, in 1955, some 15 million doses of vaccine have been given throughout the world, and there has apparently been only one accident.

THE PRESENT POSITION

This is the clinical background against which the Stockholm recommendation takes its proper place. What, then, are the implications, for Britain, of the recommendation? There are two implications that must be considered before any decision can be made. The first arises from the fact that the recommendation is addressed to those countries *"with a high incidence of paralytic poliomyelitis"*. Is Britain one of these countries? It is extremely difficult to answer yes or no, because the incidence is on the borderline between low and high. Thus while we enjoy rates considerably lower than those for North America and Scandinavia, we suffer much higher rates than most of the rest of the world. Thus the decision must rest entirely with the health departments. The second implication arises from the reservations to the main recommendation. There are three reservations:

(i) that the vaccine should be made from strains of poliomyelitis virus chosen to be as non-virulent as possible;

(ii) that experience and skill in production and testing of the vaccine must be assured; and

(iii) that great care in diagnosis is essential, since diseases resembling poliomyelitis may be diagnosed as poliomyelitis and may consequently be regarded as "vaccine failures".

The first reservation arises from the fact that the vaccine, as originally made in the U.S.A., contains a very virulent strain of virus called the Mahoney strain. It was this strain which caused nearly all the paralytic cases of poliomyelitis resulting from the Cutter accident; in case another manufacturing accident occurs, it is clearly much safer to use a less dangerous strain. *It has already been decided that no vaccine containing the Mahoney strain will be used in this country.* The other two reservations scarcely apply to Britain; they are aimed at the less well-developed countries with more limited resources, both in the laboratory and in the hospital, than we have. We may therefore take it that, insofar as the reservations are concerned, any programme undertaken in this country would meet the standards set at Stockholm.

The main recommendation at Stockholm is based, as we have seen, upon a faith in the safety and protective

power of the vaccine. The health authorities in this country are not, of course, in any way bound to concur with this view. It is difficult to believe, in the light of clinical experience that a safe vaccine cannot be made, but one must ensure that a safe vaccine is *always* made—in other words, that no possibility of a further accident remains. Many people believe that this has already been accomplished, but some do not. The last fears can never be eliminated and memories of the Cutter accident will linger. It is impossible to discuss here the details of the control measures that are being taken to ensure safety; it is possible, however, to state flatly that no health authority would consider releasing vaccine for use unless it were convinced of its safety beyond any reasonable possibility of doubt.

The protective power of the vaccine can also be questioned. As we have seen, the 1954 trial convinced even the most sceptical statisticians that the vaccine would protect at least 60% of those receiving it. The 1955 experience has added little to this evidence. Furthermore, nearly all the experience has been with children over 6 and there is no good evidence of protection in younger children. In this country, the peak incidence of paralytic poliomyelitis is in children aged 3–5, and any measure to eradicate poliomyelitis must be aimed primarily at the under-6 group. Further study of this age group is then very necessary. We must remember that, unless it is obtained, we may go on vaccinating for many years without ever being sure whether we are using a vaccine that is really effective in young children. On the other hand, although poliomyelitis is less common in older children and adults, when it does strike it is usually more severe. Consequently, with the evidence we already have of the protective power of the vaccine in these older individuals, a case can be made out for protecting them as soon as possible.

The problems that face health authorities in this country and elsewhere are thus neither few nor easy. They must try to reconcile the varying facets of the situation. We may be sure that they are aware of them all, and that they will do their utmost to plan so as to reduce the number of cases of paralytic poliomyelitis as much as possible and as soon as possible.

PHOTOPERIODISM AND ITS PRACTICAL IMPORTANCE

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From time immemorial men have wondered at the ordered sequence of changes which occur in Nature with the march of the seasons, and the fertility rites of primitive societies were closely bound up with these changes. We no longer attach any special *mystique* to these natural phenomena, however, and take it for granted that daffodils flower in April, grasses in June and July (hay-fever time!), and Michaelmas daisies in September. But what determines the characteristic time of flowering in each plant species? Is the development of the plant determined by some "internal" mechanism—a kind of natural "alarm clock"? If so, how can we explain the close synchronisation between the developmental cycle of many plants and the seasonal climatic changes (unless we are prepared to postulate some sort of "pre-established harmony" between the two)? Is it possible that the changes in the plant are in some way geared to and determined by the seasonal changes in the external factors, such as temperature, light and rainfall?

Botanists first seriously began studying these problems about forty years ago. We now know that the answers vary according to the type of plant we are studying. It is possible that an "internal" mechanism does control certain aspects of development in some plants. In many plants, however, external factors such as temperature and light have an overriding influence on their development. Light affects many processes occurring in plants; the most important of these is photosynthesis, the process whereby carbohydrates are formed in the leaves from carbon dioxide and water in the presence of sunlight. One way in which light may affect flowering is via this process of photosynthesis. For example, the formation of flower-buds in apples is promoted by light—gardeners know that branches of apple trees which are heavily shaded do not produce as much blossom as those in full light. This is because sugar and other carbohydrates, formed in the leaves during photosynthesis, are necessary for the formation of flower-buds.

But light has other effects on plants. Thus, it is now recognised that the *daylength* conditions to which plants are exposed have profound and often dramatic effects upon them. For example, some plants will flower only when the days are short, as with late chrysanthemums and Michaelmas daisies. These are called *short-day* plants (Fig. 2). Other plants remain vegetative under short-day conditions but flower when exposed to long daylengths, and hence are called *long-day* plants (Fig. 1); examples are lettuce, spinach and many grasses. This phenomenon is known as *photoperiodism*, which may be defined as the capacity of plants to show well-marked responses to the daylength conditions in which they are growing.

Flowering is not controlled by daylength conditions in all plants, however, and there is a large group of species which will flower under both long and short days. These *day neutral* species include many common

plants such as certain varieties of roses, apples, antirrhinums and "geraniums".

Readers will ask what is meant by "short-day" and "long-day" conditions. While many photoperiodic species have very precise daylength requirements for flowering, these requirements are affected by the temperature and other associated conditions and also vary from species to species, so that no universally applicable values can be assigned to the terms "long day" and "short day". We can, however, define short-day plants as those in which the flowering stage is reached earlier the *shorter* the day (within certain limits), while long-day plants are those in which flowering occurs sooner the *longer* the day. On this definition short-day and long-day plants are quite distinct and do not grade into each other.

Although, as we shall see later, photosynthesis is involved in photoperiodism, the daylength effects are not due simply to differences in the amounts of carbohydrate formed during different periods of photosynthesis, but result from some rather specific and finely-balanced processes controlling flowering.

As might be expected, many short-day plants are tropical or sub-tropical; examples are rice, maize, soya-beans, cotton and sugar-cane. The short-day plants of temperate regions are usually late-flowering species, which remain vegetative throughout the summer and only form flowers as the days shorten in the autumn, e.g. ivy and golden rod. More commonly we find that the plants of temperate regions are long-day types. In addition to the examples already given, this latter group includes many of the plants flowering in high summer, such as China aster, red campion and heather.

Flowering is not the only process which is affected by daylength conditions; thus the formation of tubers by potatoes, dahlias, and Jerusalem artichokes is hastened by short days. On the other hand, onion plants form bulbs only under long-day conditions—under short days we get nothing but "spring onions". Daylength conditions also have a profound effect upon the growth of trees, many of which continue active growth under long-day conditions, but cease growth and lose their leaves under short days (Fig. 3). It has frequently been observed that trees growing in the vicinity of street lights, so that they are exposed to artificial long-day conditions in the autumn, often retain their leaves for several weeks longer than normal.

The discovery that seasonal variations in daylength have an all-pervasive influence on many aspects of plant development must be recognised as one of the

FIG. 1. These plants of the cone flower (*Rudbeckia*) are both from the same batch of seedlings, but the left-hand plant has been grown under "long days" and the right-hand plant under "short days" (9-hour day). Notice that the "short-day" plant has remained vegetative and the stem has become telescoped, giving a "rosette" type of growth. This is normally a summer-flowering plant.

FIG. 2 (*below*). The succulent plant *Kalanchoë Blossfeldiana* is a short-day plant and remains vegetative under "long-day" conditions, but flowers with day-lengths of 12 hours or less. It therefore flowers in the winter when grown in the greenhouse in Britain.

major advances in contemporary botany. Seasonal variations *in temperature* are also known to have a profound effect on flowering and other developmental processes in plants, but space does not permit a discussion of this subject. It should be mentioned, however, that winter-chilling promotes flowering in many species (an effect referred to as "vernalisation"), and some plants, e.g. chrysanthemum, have special requirements with regard to both chilling and daylength, which must both be fulfilled before they will flower. Major contributions in this field have been made by Prof. F. G. Gregory and his co-workers at London's Imperial College of Science and Technology.

THE PROCESSES UNDERLYING PHOTOPERIODISM

Intensive study of photoperiodism in many countries has yielded a large body of facts, but we are still a long way from fully understanding the nature of the processes underlying the manifold visible effects. Nevertheless, some progress has been made in recognising a number of distinct stages in the processes leading to flowering. Let us deal firstly with *short-day plants.* It may be asked whether the responses of short-day plants are determined primarily by the shortness of the light period, or by the length of the dark period. When the length of a single cycle of light and darkness is fixed at 24 hours, it is impossible to answer this question, since an increase in the length of daily light period automatically results in a reduction in the length of the dark period. By using artificial light sources, however, it is possible to vary the length of the light period while the length of the dark period is kept constant, and vice versa. By experiments of this type it has been possible to show that in short-day plants, the response is determined primarily by the length of the daily dark period, i.e. short-day plants flower when the dark periods exceed a certain duration. Hence they might more appropriately be called "long-night" plants. Thus, many varieties of chrysanthemum will flower when the dark period exceeds about 8½–9 hours. Although some short-day plants can be induced to flower in continuous darkness, in all short-day plants flowering is greatly promoted if there is regular alternation of light and darkness; this means that both light-promoted and dark-promoted processes are involved in the flowering responses of short-day plants. It appears that the primary light-promoted process is actually photosynthesis—this results in the formation of the necessary respiratory substrates required before the dark-controlled processes can occur. The intensities involved in these *primary* light requirements are relatively high, i.e. of the same order as that of natural daylight.

A very interesting feature of the "dark" processes is that they are more or less completely nullified if the dark period is interrupted by quite a short period of illumination—even a few minutes of light given in the middle of a long dark period are sufficient to suppress the flowering of short-day plants. Alternatively, if longer periods of artificial illumination are used to supplement a period of daylight, quite low intensities

FIG. 3. There are seedlings of the false acacia tree (*Robinia pseudacacia*). Notice that the plant kept under long-day conditions is still growing actively, whereas the plant exposed to "short days" has ceased growth (but has not yet dropped its leaves). It is the onset of short days in the autumn which causes the cessation of growth in many tree species.

(of the order of one foot-candle) are sufficient to suppress flowering in short-day plants. Such low intensities can have only a negligible effect on photosynthesis, and it appears therefore that, in addition to photosynthesis, a *second* light-activated process is involved. We thus have the apparently paradoxical situation that light has two opposite effects upon the flowering of short-day plants—a certain minimum period of photosynthesis preceding the dark period is necessary for flowering, but once the dark processes have commenced light has a markedly *inhibitory* effect on the formation of flowers.

The spectral requirements for the low-intensity light reaction have been worked out in considerable detail by Dr. H. A. Borthwick and his co-workers at the U.S. Department of Agriculture research station at Beltsville, Maryland. They have found that the red region of the spectrum is the most effective in suppressing flowering in short-day plants. The spectral requirements suggest that the light is absorbed by a blue-green pigment, but attempts to identify this pigment have so far been unsuccessful. These spectral studies have recently been extended to light-sensitive seeds and have led to very interesting discoveries. It has long been known that the seeds of some plants require light for germination—this applies, for example, to seed of certain varieties of lettuce at temperatures above 20°C. It has now been found that the regions of the visible spectrum most

FIG. 4. Long-day conditions may be reproduced artificially in winter by supplementing natural daylight by quite low-intensity illuminations, so that the plants are exposed to long "days" and short "nights". In the experiment illustrated above, the plants of spinach (a long-day plant) all received an initial period of 10 hours of white light, which was then supplemented by 8 hours of low-intensity light of various colours. It is seen that the most effective part of the spectrum in stimulating flowering is a band extending from the yellow-green to the red (5000–7000 A.). *(Courtesy, Dr. J. A. J. Stolwijk.)*

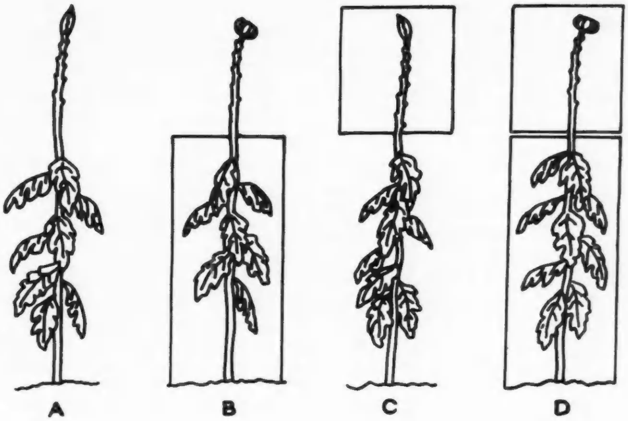

FIG. 5. This diagram illustrates an experiment demonstrating that the photoperiodic response of a short-day plant such as chrysanthemum is determined primarily by the daylength conditions to which the *leaves* are exposed. The leaves were removed from the upper part of all the plants, so that the growing points and remaining leaves could be exposed independently to either long or short days. The treatments were as follows: Plant A—Both growing points and leaves exposed to *long days*. Plant B—Growing point exposed to *long days*, leaves to *short days*. Plant C—Growing point exposed to *short days*, leaves to *long days*. Plant D—Both growing points and leaves exposed to *short days*. It is seen that only plants B and D produced flowers, indicating that the daylength conditions are "perceived" in the leaves and that some flower-inducing stimulus is transmitted from the leaves to the growing points.

effective in stimulating germination correspond very closely with those which are effective in controlling the flowering of photoperiodic plants, i.e. the red part of the spectrum. Moreover, the Beltsville workers have discovered that the effect of a period of exposure to red light can be nullified if it is immediately followed by a period of infra-red radiation. In other words, red radiation promotes germination whereas infra-red radiation inhibits it. If alternate periods of red and infra-red are given, the final effect on germination is determined by whether the *last* exposure is red or infra-red.

Having made this discovery with lettuce seed, these workers proceeded to re-examine what happens with short-day plants when the dark period is interrupted by a short period of red light. They again found that it was possible to reverse the effect of red light by infra-red radiation. That is, whereas red light tends to inhibit flowering, infra-red during the dark period tends to enhance the flowering response.

It is clear, therefore, that the basic low-intensity reaction involved in both light-sensitivity of seeds, and in photoperiodic effects must be identical. The close relationship between light-sensitivity of seeds and photoperiodism has now been directly demonstrated by the observation that germination of some seeds can be photoperiodically controlled, e.g. seed of birch is light-requiring and full germination is obtained with long-day conditions, whereas under short days there is very little germination of the seeds.

In many respects, *long-day plants* appear to be the "mirror-image" of short-day plants. Long-day plants have no minimum dark requirements and they flower most rapidly under continuous light. The failure of long-day plants to flower under short days apparently arises from the inhibitory effect of long dark periods. They can be induced to flower, however, if such long dark periods are interrupted by short "light-breaks". As in short-day plants, the red region of the spectrum is most active in this effect (Fig. 4). Thus, the low-intensity photo-reaction has opposite effects in long-day and short-day plants.

EVIDENCE FOR "FLOWER HORMONES"

It will be seen that we are beginning to gain some knowledge of the light and dark reactions involved in photoperiodism. It is clear, however, that between the occurrence of these initial light and dark reactions and the ultimate expression of flowering, there must be many processes about which we know nothing at present. Nevertheless, for nearly twenty years there has existed evidence which suggests that one of these intermediate processes involves the production of some specific flower-forming substances in the leaves of photoperiodic plants. It has been known for some time that although the change from the vegetative to the flowering state must ultimately occur at the growing points of the plant, nevertheless, the response of the growing point is determined primarily by the daylength conditions to which the *leaves* are exposed (Fig. 5). Thus a short-day plant will flower if the *leaves* are exposed to short days, regardless of the daylength conditions under which the short-apex is maintained. This led to the suggestion by the Russian botanist M. C. Cailachjan that some flower hormone (which he called "florigen") must be transmitted from the leaves to the growing points, where it induces the change to the flowering condition. The evidence for the transmission of some flowering stimulus from *induced* leaves is extremely strong. Thus, a leaf from a flowering plant of the American "cocklebur" (*Xanthium pennsylvanicum*) can be removed and grafted to a vegetative plant maintained under long days, and the latter will then flower, although the second plant has never itself been exposed, to short days. Similarly, a flowering scion can be grafted on to a vegetative stock which is then induced to flower, although it has never been exposed to flower-inducing daylengths. It is difficult to explain these facts except in terms of some flower-promoting substance which is transmitted from "induced" leaves, and it seems justifiable to postulate a specific flower hormone. This flower hormone would seem to be of a similar nature in different plants, since it is possible to graft a leaf from one plant (e.g. tobacco or petunia) on to a vegetative plant of a

different genus (e.g. henbane) and still obtain flowering of the latter.

Plant physiologists were not slow to recognise the great theoretical significance and possible practical importance of these discoveries. Clearly, if the hormone could be isolated in a pure form and its chemical nature determined, we should be a great step towards controlling flowering at will, and the agricultural and horticultural implications might well be revolutionary. Nevertheless, although repeated attempts have been made to isolate a flower hormone, all such efforts have so far been unsuccessful. This failure to isolate a substance capable of inducing flowering in vegetative plants is baffling, but there are several possible explanations; the three main ones are as follows:

1. The hypothetical hormone may be present in extremely low concentrations, or it may be very unstable, so that existing methods of extraction and detection are not sufficiently sensitive.

2. Since the naturally occurring *growth hormones* are relatively simple compounds, it has generally been assumed that the hypothetical flower hormone will also prove to be a fairly simple substance. There is no reason, however, to exclude the possibility that "Florigen" is a complex protein or nucleoprotein. If so, special techniques would be required to detect it, especially if it is present in low concentrations. Attempts, in Germany and elsewhere, to detect differences between the proteins of flowering and non-flowering plants of *Xanthium pennsylvanicum*, and of other species, have so far given no clear-cut results, however.

3. There may be no specific flower hormone—the induction of flowering may depend rather upon *quantitative* differences in the level of certain well-known substances occuring in plant tissues. On this view, the "flower hormone" may be an already well-known substance.

This last explanation is the one favoured by those who believe that the growth hormone "auxin" (generally held to be indole-acetic acid or related substances) plays a determining rôle in the control of flowering, as well as several other basic processes of growth and development. Some plant physiologists hold that flowering depends upon the occurrence of a certain critical level of auxin in the leaves and that the daylength conditions affect this level. It is thought that the auxin level is too high for flowering in short-day plants kept under long days, and too low in long-day plants kept under short days. Although there is evidence to support these views, there are also certain difficulties which render them unacceptable to many physiologists and the question as to how far daylength conditions can affect the auxin metabolism in the plant must still remain open for the present.

PRACTICAL IMPORTANCE OF PHOTOPERIODISM

Photoperiodism has an important bearing on many practical problems and its importance is likely to grow as our understanding of the subject increases. Thus, it is now clear that when we introduce a plant into a new region of cultivation it must be suited not only to the new conditions of soil, temperature and rainfall, but also to the daylength conditions. A new species may fail in its new habitat simply because the days are too long or too short, even though all other conditions are favourable. For example, when we introduce short-day plants such as sweet corn into this country, we must select types adapted not only to the lower temperature conditions here, but also able to tolerate the longer days. Similar considerations are important when new species of forest tree are introduced. Conversely when vegetables of temperate regions, e.g. onions are introduced into the tropics, it is necessary to select suitable strains adapted to short days. Now, it is well established that considerable variability exists in many plant species with respect to photoperiodic response. There is therefore ample scope for selecting different strains. The occurrence of such variation is well shown in plants in which a whole range of varieties exists which mature at different times. Thus, for example, there are the early varieties of potatoes which form tubers even in long-day conditions, whereas the late varieties usually need short days. Similarly, early chrysanthemums will flower under long days, whereas late chrysanthemums have greater short-day requirements. Photoperiodic effects have also to be taken into account in selecting varieties for growing at different seasons. Thus, winter varieties of lettuce cannot be used in the summer since they rapidly "bolt" in the long-day conditions, and it is therefore necessary to use other varieties which show less tendency to do this.

It is now possible to control the flowering of photoperiodic plants at will, so that flowers of any given species can be produced all the year round. This is particularly important to the plant breeder, since it enables him to make crosses between plants which normally flower at different times. It also helps to speed up the breeding programme, since in many cases it makes it possible to obtain more than one generation per year by inducing early flowering by photoperiodic treatment. It would be feasible to produce out-of-season crops of many plants for commercial purposes, but so far this possibility has not been generally exploited. Some growers delay the flowering of their chrysanthemums by long-day treatment so that they can take advantage of the Christmas market. It is interesting to note that they achieve long-day conditions by interrupting the night with quite a short period of illumination. This is just as effective as continuous illumination and saves electricity.

These examples must suffice to illustrate the many practical implications of photoperiodism, but the possibilities would be enormously enhanced if only we could isolate the flower hormone!

FURTHER READING

Loomis, W. E., *Growth and Differentiation in Plants*, Iowa State College Press, Ames, Iowa, 458 pp., 1953.

Lang, A., "The Physiology of Flowering", *Annual Review of Plant Physiology*, 1952, vol. 3, pp. 265–70.

THE HEAT PUMP AND ITS APPLICATIONS

M. V. GRIFFITH, B.Sc., F.Inst.P.

The heat pump is often referred to as a means of getting "something for nothing". This is not really true. Radiation from the sun is absorbed and stored in many different ways after it has passed through the earth's atmosphere. All the materials now used as fuels contain this stored energy in a very concentrated form, but thousands of years and often great pressures and temperatures have been necessary for this condition to be reached. The air, the soil of our fields and gardens, the waters of the earth, all of which we think of as cold, are, however, continuously kept by the heat of the sun at a level of temperature well above that of the regions outside the atmosphere. This is to say that rivers, lakes and other natural bodies, by virtue of the difference between their temperature and absolute zero, possess heat energy, much of it useless. The heat pump is a thermodynamic trick that enables us to take this useless heat from them and get it "pumped up" to a useful temperature level, useful in that the heat can now be used for space, water or process heating.

In the past ten years or so interest in the possibilities of the heat pump in this country has grown considerably. Before that period, from the time of the inception of the idea by Lord Kelvin in 1852, any development had followed the usual custom of many British inventions in taking place largely overseas, notably in Switzerland and the U.S.A. There has been some excuse for this apparently dilatory behaviour in the past but present circumstances have altered the picture considerably.

Lord Kelvin's original suggestion was that a machine could be made which would perform a direct heat exchange between the air outside and the air in a room. He showed by mathematical argument that the applied power required to operate such a machine would be only a fraction of the total quantity of heat which could be made available by this operation. On the basis of his resulting equation, if one assumes that it is possible to construct a perfect heat pump, air at 50°F could be cooled and hot water at 135°F provided for a rate of energy consumption only about one-seventh of that required to heat the same volume of water to this temperature by direct means, such as an immersion heater. If the air were at 30°F, the input energy required would be increased to one-sixth of the heat output, whereas with an air temperature of 70°F, this input energy would be reduced to about one-ninth of the output. These figures are based on a perfect or ideal heat pump with no losses.

The first machine was made on this principle nearly a century ago, but its heat output was less than the equivalent of the energy required to drive it. This was partly due to the use of the air itself as the working substance. A machine of this type must be very large if it is to deal with appreciable quantities of heat, and in consequence friction and other losses become comparatively great. The discouraging result of this experiment, together with the cheapness of coal and labour at the time, led to the temporary abandonment of the system for heating.

Meanwhile the study of methods of food preservation led to the use of the same principle for bulk cold storage. The direct air-to-air cycle was replaced by the more efficient and convenient vapour compression cycle both for this purpose and for many domestic refrigerators.

The chief advantage of using a working fluid or refrigerant as an intermediary between the cooling and heating processes is the resulting reduction in size of the machine. The bulk of the working fluid is very much less if the changes of state from liquid to vapour and vapour to liquid are utilised for the heat transfer instead of the heating or cooling of large volumes of air with its low specific heat. The heat exchangers required for a system utilising the direct compression and expansion of air would be of the order of one hundred times the size of those required for a vapour compression system.

A domestic refrigerator can be considered to be a small heat pump, and a survey of its more familiar processes may assist in an understanding of larger space-heating units. Fig. 1 shows a simplified diagram of the operation of a domestic refrigerator. Heat is absorbed from the food in the insulated enclosure by the refrigerant, which circulates through the walls

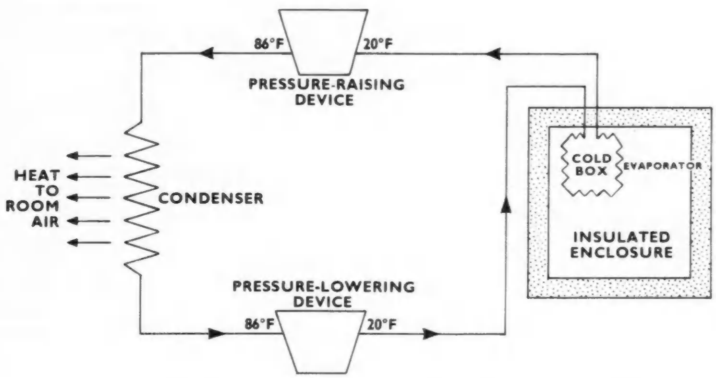

FIG. 1. Simplified diagram of refrigerator operation. In the heat pump the evaporator in the insulated enclosure is replaced by buried or immersed coil of pipes.

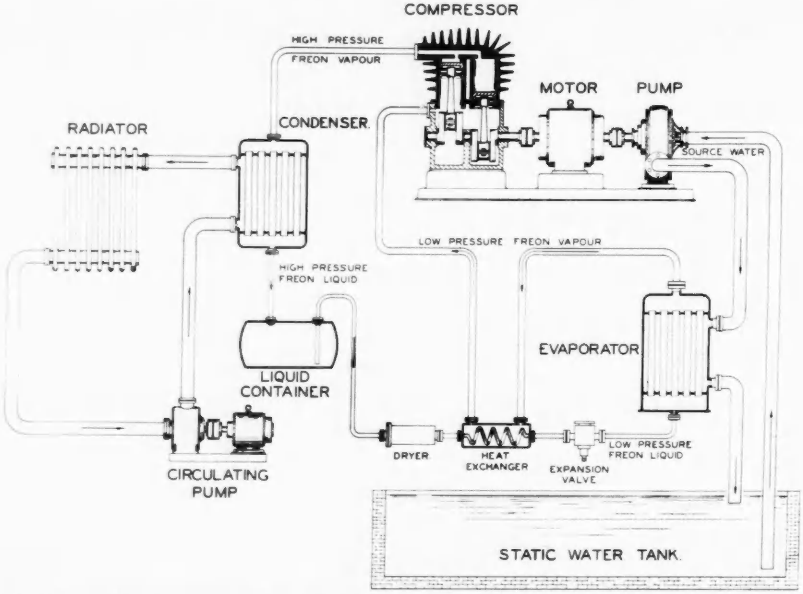

FIG. 2. SCHEMATIC LAYOUT OF HEAT PUMP.

of the freezing compartment or cold box. This fluid, which is in the liquid state, has passed through a pressure-reducing valve before entering the walls of the cold box and the resulting expansion has lowered its temperature and also its boiling-point. As the food is cooled, it gives up an amount of "low-grade" heat which is just sufficient to boil or vaporise the liquid refrigerant if the quantity of this passing through is correct. The withdrawn "cold" heat is now contained in the vapour as latent heat of evaporation.

To get rid of this heat, the temperature of the vapour must now be raised above that of the atmosphere surrounding the refrigerator. This is most conveniently contrived by raising the pressure of the vapour by means of a motor-driven compressor, since the increase of pressure also raises the boiling-point of the refrigerant. The vapour will therefore condense at the higher temperature, all the latent heat being given up in the process. The resulting liquid then passes to the pressure-reducing device and the process begins again.

To translate the operation into that of a heat pump requires only a change of emphasis. The prime objective in the first is efficient cooling, with the actual temperature rise necessary for rejection of the absorbed heat a secondary consideration. In the heat pump we concentrate our attention on the preservation of this absorbed heat until it reaches the space which we want to be warmed. The temperature of condensation will be higher and therefore the pressure increase of the vapour must be much greater than that used in a refrigerator. All that is required of the source of low-grade heat is that it shall be conveniently available and ample in quantity.

A similar process to that which has been described for the refrigerator takes place in the vapour compression heat pump. In place of the food, large bodies of water (e.g. rivers and lakes), or large volumes of soil or atmospheric air, are cooled by means of coils of pipes which contain a circulating refrigerant at a low pressure and temperature. The heat absorbed through the walls of this coil (the evaporator) vaporises the refrigerant, which then passes on to a compressor where its temperature and boiling-point are raised as before. The lower temperature of the refrigerant must be arranged to be less than that of the medium surrounding the heat-absorbing coils, and the higher temperature must be sufficient to provide the heating services required. The drop in pressure between the two heat exchange processes takes place through an orifice in an expansion valve. The practical system is illustrated in Fig. 2.

Suitable refrigerants for heat pumps must have certain characteristics. The latent heat (usually given in British Thermal Units per pound) must be high to ensure minimum bulk. A suitable fluid will boil and condense at the desired temperatures under pressure conditions which are easy to attain. For example, it is better not to have a vacuum at the low temperature end of the system because of the danger of absorbing air if a leakage should occur. If too high a pressure is required to enable the desired upper temperature to be provided, the compressor and condensing heat exchanger will have to be made very strong, thus using a greater quantity of material. Moreover, the efficiency of the compressor will fall if the difference in these two pressures is too great.

Some values of the ratio of output heat to input energy were given earlier for an ideal heat pump working over various temperature ranges, but several factors combine in practice to reduce this ratio. The physical

characteristics of the refrigerants used reduce it by 10–15%; the necessary temperature difference across the walls of practical heat exchangers reduces it by a further 15%. The mechanical efficiency of the compressor and motor system will depend on the size of the plant and will vary from 50 to 75% for the compressor and 50 to 90% for the motor.

The combination of these factors results in a practical value of the ratio of heat output to energy input being only about 50% of the theoretical maximum. The net effect can be illustrated by the following example:

If we have a considerable quantity of a material at a non-useful temperature, say 50°F, and a heat pump, we can obtain a quantity of hot water, at say 140°F, for the expenditure of only one-third of the electrical or other energy which would have been needed to heat the water by direct means. If, however, we have a source of waste heat (for instance, cooling water from some industrial process, at say 80°F), we need supply only one-fifth of the energy normally required to heat the hot water. Various names have been given to the ratio which is so important a characteristic of the heat pump operation. The term now preferred by many workers is Performance Energy Ratio (PER).

DESIGNING A HEAT PUMP

In its present stage of development the heat pump for space-heating involves a higher capital cost than other equipment used for the production of heat. In countries where air-cooling is necessary in summer, the heat pump comes into its own, since its operation can be made reversible. In other words, the source of low-grade heat which is cooled for winter use can be made to absorb the heat from the house or building in summer. The ability to fulfil this dual role completely justifies the high capital cost.

In Britain the method must be considered primarily in terms of the heating function. It is essential therefore for the design of individual machines to be very accurate since over-capacity is costly.

The present capital cost of a heat pump can be divided into four roughly equal parts covering the costs of the following items: (*a*) the compressor and driving mechanism with control gear; (*b*) the low-temperature heat exchanger (with its pump or fan); (*c*) the high-temperature heat exchanger (with its pump or fan); (*d*) the refrigerant, pipe-work, pressure-reducing valve, safety devices and heat distribution system. To the cost of item (*b*), if a source of low-grade heat (such as the air, a river or a well) is not conveniently available, we must add the cost of well-sinking, burial of ground coils or some other alternative.

Space-heating by means of warm air is very suitable for use with the heat pump, because the output temperature is lower than that required for water heating. It is not yet very popular in this country, however, and the necessary fans use more power than a pump.

Some hundreds of heat pumps have been constructed in various parts of the world in the past few years. Their performance has varied considerably. In the case of small residential units, American investigators have

FIG. 3. An American "package unit" heat pump for domestic heating by means of warm air.

found that disappointing performance can usually be traced to bad air duct design, wrong water pump capacity or to inadequate evaporator area.

One of the points usually raised in favour of the heat pump is that it can be made completely automatic. This is so, but this feature, of course, raises the capital cost. The equable climate of Britain helps design considerably, but it is generally found that the most economical system of control from the point of view of varying heat requirements is to stop and start the compressor motor by thermostat.

AVAILABLE SOURCES OF HEAT

Some natural sources of low-grade heat such as rivers and wells have already been mentioned. Even in very wintry conditions, water at 38°F can be obtained from rivers if the supply is drawn from a depth of a few feet. Somewhat higher temperatures will be available where waste heat from factories and power stations warms up the river or lake.

The average winter air temperature in Britain is 40–45°F. The use of external air, however, although very convenient, is complicated by the prevalence of high humidity, which will result in large deposits of frost on evaporator surfaces. Defrosting arrangements can be made, but it is better, where possible, to employ used internal air.

Extraction of heat from the soil by means of buried

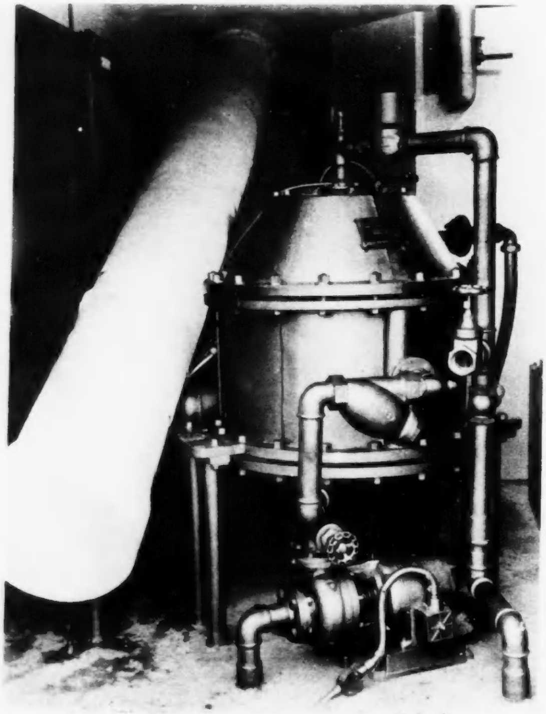

FIG. 4. A heat pump used for laboratory space-heating; the soil provides the necessary low-grade heat. (*Electrical Research Association photograph.*)

chilled pipes has proved to be more efficient than was at first thought possible, though there is plenty of room for further research and development in this connexion. At this stage it can be stated that low-grade heat can be absorbed from the soil at the rate of one kilowatt per 100-foot length of buried pipe ($\frac{3}{4}$-inch diameter).

Industrial waste water at temperatures between 60°F and 100°F is clearly the best type of source for the heat pump, provided it is not corrosive. The Performance Energy Ratio of heat pumps utilising such water reaches at least 5. On a smaller scale, hot water contaminated in use and then sent to waste (e.g. in hospitals, hotels, restaurants and houses), contains up to 90% of the heat originally put into it and the salvage of this heat is worth considering.

In urban areas electrical substations need expensive ventilation because of the heat from distribution transformers. There are generally commercial premises at hand which require heating. Most of the energy supplied to underground railways is released as heat and stored in the surrounding soil, while in deep mines refrigeration is required to improve conditions. In two of these three cases expensive cooling arrangements are essential. Hot water could be provided if the cooling was carried out by means of a heat pump. In the case of mines this water could be conveniently used in pithead baths.

EXAMPLES OF HEAT PUMP APPLICATIONS

There is no argument about the operability of actual heat pumps. In Switzerland, all the plants described in the literature are fairly large and their use needs no justification, since electricity is cheaper than coal, but needs to be used economically. Some of the smaller ones provide hot water by making ice in public rinks.

There is another very advantageous use of the heat pump method, originally developed in Switzerland, which is creating some interest in Britain. In this method, the latent heat contained in the vapour given off by a boiling liquid is utilised by compressing the vapour so that its temperature rises. The vapour is then passed through a coil immersed in the new charge of liquid to be heated and in which it condenses. A starting heater is used to begin with, but the performance ratio after this is very high. Figures for a water distillation system show that only 78 kilowatts were needed to evaporate 278 gallons per hour at a PER of 12·8. This method is also very suitable for the concentration of thermolabile substances like milk.

At least four types of heat pumps installed in office buildings in America have capacities of the order of 500 h.p. input, and all are economic propositions. For instance, a 225 h.p. heat pump using air as a heat source has been operating for several years in a building of 1 million cubic feet. The air exhausted from the building then acts as a heat source for a small heat pump that supplies hot water to a garage; the same hot water can also be used for snow melting. In addition to such large units several very neat types are available in the U.S.A. which appear to provide adequate service. For example, a machine driven by a 3 h.p. motor is being used to heat small well-insulated houses; the performance quoted averages about 2·8 per heating season.

The heat pump plays a dual role in some American applications. Thus the food coolers in one "supermarket" supply hot water which circulates through piping buried in the floor, and this serves as background heating.

HEAT PUMPS IN BRITAIN

In Britain, of course, the most famous installation is the one which Mr. J. A. Sumner installed at Norwich. Heat is taken from the River Wensum which flows past the basement of the local Electricity Offices and is used to heat that building. The original plant was driven by a 45-kilowatt D.C. motor and used sulphur dioxide as the refrigerant. It provided much useful data but needs to be renewed, as some of the second-hand parts used in its construction are now worn out.

Two generating stations in the Midlands have offices and workshops that are warmed by heat pumps. The heat is abstracted from the water used to cool the turbine condenser. The temperature of this water is relatively high and the PER should correspond. At one of these stations hot water is used as the heat-distributing medium, and the other uses heated air.

Since March 1945, the Electrical Research Association has taken an active interest in the heat pump, and a test plant was set up at Perivale in West London in

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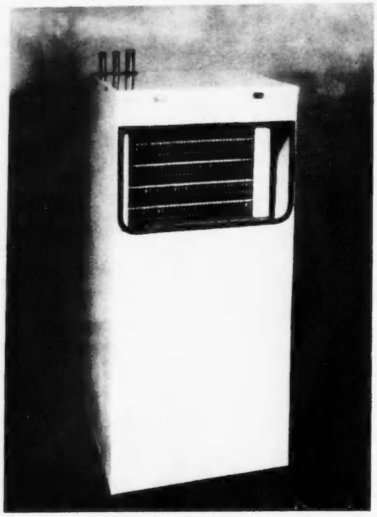

FIG. 5. Two British larder-cooling heat pumps. (*Left*) The Ferranti Fridgeheater. (*Right*) The Brentford Duo-Therm.

1947. The Association has since installed another plant at its Agricultural Field Station near Reading.

The activity of the ERA was inspired by a desire to examine thoroughly any project which showed promise of giving economy in the use of electricity for heating purposes. The application of the results need not be restricted to electrically-powered installations, however. Diesel engines may be used, for example; in this case greater economy in basic fuel might be obtained, since the waste heat from the engine could be added to the heat pump output. The Festival Hall heat pump was of this type, a gas engine being used to drive the compressor.

THE ELECTRICAL ASPECT

There is no need to emphasise the importance of the elementary energy ratio—an output of 3–4 units of heat energy for every unit of electricity consumed. Electrical space heating with its manifold advantages becomes as economical (in terms of the amount of coal consumed at the generator) as the most efficient solid-fuel heating appliance. But, unfortunately, at the moment the capital cost is not quite so favourable.

This cost does not matter so much for large plants where amenity has its definite price. For residential units, the price is still relatively high and needs to be reduced.

Another use of the heat pump is as a water heater to do a job comparable to that performed by a kitchen or bathroom geyser. Such units are driven by fractional horse-power motors; these can be obtained with the compressor hermetically sealed in an outer casing, so that the complete unit (except for the evaporator) can be immersed in a tank of water, with the result that all the waste heat from the motor goes into the water. In addition, the ordinary domestic larder forms an adequate heat source if about 40 gallons of hot water is required a day. This dual-purpose unit has a capital cost which does not exceed the combined costs of a refrigerator and a domestic water heating system. Two commercial models of this type of heat pump are on the British market. A similar unit has been tested for use in dairies: the heat source in this case is the warm milk which in any event has to be cooled.

The future of the heat pump in Britain seems likely to lie with those applications where the temperature level of the source and the temperature level required in the output medium are so related that high performance ratios result. The capital cost is still the bugbear, and some of the current research effort is devoted to this aspect. At present a conservative estimate is £40 per kilowatt-equivalent of output heat for large plants. For small units the figure may need to be doubled. Indirect benefits (such as cleanliness, no fuel storage and low maintenance costs) must, however, be taken into account in any comparisons. We shall probably have to choose eventually between simple and direct methods leading to high reliability and more complex arrangements giving somewhat higher efficiencies. In particular, dual-purpose applications where refrigeration is already necessary should be developed.

READING LIST

Readers interested in obtaining further details could consult the three following books:

Heat Pumps by Ambrose, Sporn and Baumeister (Collins, London).

Heat Pump Applications by S. Oglesby and E. N. Kemler (McGraw-Hill, New York and London, 1950).

Heat Pumps and Thermal Compressors by S. J. Davies (Constable, London, 1950).

The Electrical Research Association has published two reports as follows:

E.R.A. Report Ref. Y/T18. *Heat Pump Sources—Heat Transfer from Soil to Buried Pipes* by M. V. Griffith; price 12*s*. 6*d*.

E.R.A. Report Ref. Y/T15. *Characteristics of a Small Heat Pump Installation* by M. V. Griffith and H. J. Eighteen; price 15*s*.

(Both these reports are obtainable from: The Electrical Research Association, Information Bureau, Thorncroft Manor, Dorking Road, Leatherhead.)

BRITISH PLANS FOR UPPER ATMOSPHERE ROCKET RESEARCH

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The recent announcement by the Royal Society that Britain is to use rockets to carry out research at high altitudes has aroused much interest. Although the United States and Russia had a start on this country at the end of the war, it has been clear for some time that the means for carrying instruments into the upper atmosphere were to hand in Britain and that sooner or later they would become available for research purposes. In the past British physicists, both theorists and experimental workers, have made important contributions to the study of the ionosphere and upper atmospheric phenomena. It is not surprising therefore that the offer by the Ministry of Supply of rockets and rocket-range facilities for high-altitude research should have been greeted with enthusiasm, but one might wonder whether in fact a British programme can accomplish anything not already accomplished by the Americans. It is true that many spectacular discoveries have been made by the pioneers. There was the discovery of the strength of the solar X-rays or of the λ–α line emission in the ultraviolet spectrum, for example, and of the surprising brilliance of the daytime air glow when observed against the blackness of the upper atmospheric sky. These are, however, only highlights in a picture which is still largely obscure.

Some of the experiments proposed for the British programme will greatly interest DISCOVERY readers. One of the first questions to arise in this context is: can we in fact carry useful weights of equipment to adequate heights? The answer is certainly yes. The British upper-atmosphere research rocket is designed to carry a load of 100 lb. to 210 kilometres. This is a performance similar to that of the American Viking or the latest models of the Aerobee (Fig. 2), but it is expected that the British rocket will be much easier to handle. Nearly all the regions in which atmospheric phenomena of importance occur are below 210 kilometres, as can be seen from Fig. 1, which is taken from a recent *Endeavour* article by Prof. H. S. W. Massey on the nature of the upper atmosphere.

The behaviour of the upper atmosphere at greater and greater heights is in many ways like that of an electric discharge tube as the pressure is reduced towards high vacuum. At atmospheric pressure there is little evidence of electrical activity. As the pressure falls by continued pumping, or by ascent in the atmosphere, we find ionisation and photo-chemical processes occurring. At greater heights or lower pressures the activity gets less again, and the very rare atmosphere now permits almost unhindered the passage of intense solar radiations, whether photons or particles, just as the discharge tube becomes filled with streams of cathode rays. It is for this reason that the important phenomena are crowded between about 30 kilometres where the pressure is about a hundredth of an atmosphere and 210 kilometres where it is about a hundred-thousand millionth of that at sea-level.

It is clear that the British research rocket can be expected to make possible experimental study of most of the phenomena of interest. This is such a vast field that the question must arise of what to do first. In drawing up the initial programme those responsible have had two main factors in mind. Rocket research is neither easy nor cheap. An experiment in a rocket cannot be coaxed, as it can in a terrestrial laboratory. Indeed generally a dress rehearsal is impossible, so one factor to be borne in mind is the desirability for simplicity, especially while experience is being gained. A simple experiment is more likely to work first time, and if it fails we are more likely to learn from it than from a complex arrangement. The second and possibly the main factor in the choice of experiments can be appreciated by considering the following question which the research scientists asked themselves when planning this project: what gaps in our knowledge seem most urgently to need filling? In this connexion, rocket experiments can again be divided into two types—those in which the season, time of day or geographical location are important variables and those in which they are not. Study of solar radiation can be carried out equally well in the deserts of New Mexico, Australia or the Sahara, so it belongs to the second category, whereas the distribution and character of high altitude winds requires experiments in several places and at different times if the

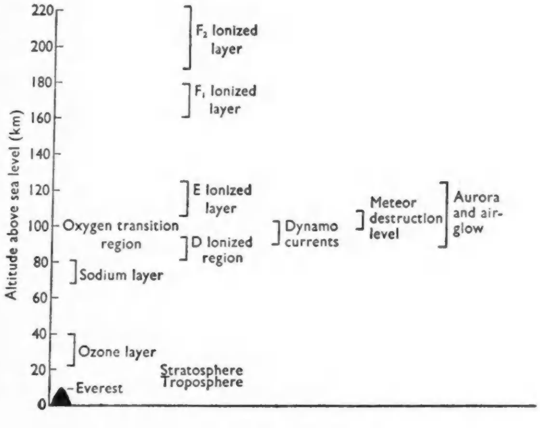


FIG. 1. The main regions of interest in the high atmosphere. The F and F ionised layers are shown separately; by day they are separate, but at night they merge. (From *Endeavour*, 1954, vol. 13, No. 50.)

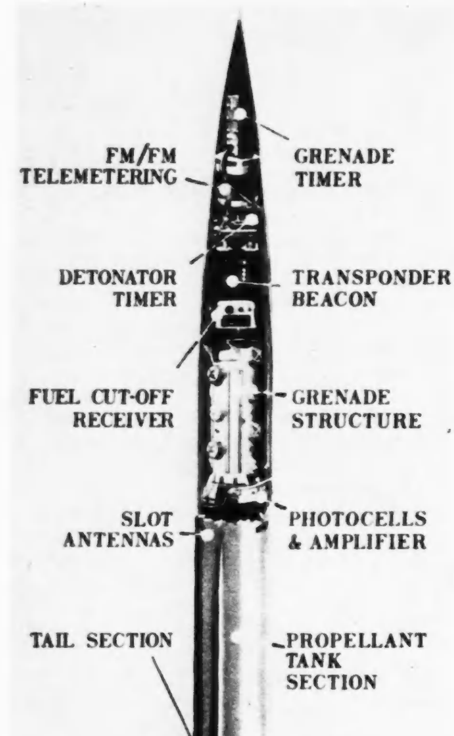


FIG. 2. A cut-away view of the Aerobee rocket indicating details of the instrumentation. The first British research rocket will be fired at the Woomera range in the second half of this year. About 25 feet long and 17 inches in diameter, its performance will match that of the Aerobee.

circulation pattern is to be discovered. Such experiments falling into the first category are very important even though they may already have been carried out in New Mexico or elsewhere. One of the first experiments in the British programme will probably be a study of high-altitude winds which are clearly of great importance for meteorology. In this experiment the actual instrumentation of the rocket consists simply of a number of grenades mounted in short, mortar-like barrels together with a timing system to eject them one at a time as the rocket ascends. On the ground microphones detect the arrival of the explosion. The position at which it occurs is observed by several cameras which record the pin-point flashes against the background of stars, whilst the instant of explosion is obtained from a photocell signal. From a knowledge of the position and time of travel of the sound from each grenade to the microphones the average speed of the sound over this path can be found. Now this speed depends upon the temperature of the air and its state of motion, that is the wind. By comparing the average speed of the sound over the paths to several different microphones the wind velocity can be found, whilst from measurements made on successive grenades the distribution of the temperature with height is derived. This is particularly suitable as a first experiment since it gives important information with very simple rocket-borne equipment. Some data has already been obtained in New Mexico using this method, but a more synoptic approach is much needed.

At various heights in the atmosphere between 80 and 210 kilometres ionised layers are to be found. These are shown in Fig. 1 labelled D, E, F_1 and F_2. It is the reflecting property of these layers for certain radio frequencies that makes long-range radio possible. For many years the electron concentration in these layers has been studied by radio methods. This means, however, leaves uncertain the actual distribution of the ionisation in height, and the nature of the charged particles present is not revealed. The character and concentration of the charged particles, particularly those carrying negative charges, constitute a serious gap in our knowledge and understanding of the processes active in these regions. Because of this it is planned to carry out several ionospheric experiments. In one of these the passage of a radio signal between the rocket and the ground will be timed. Just as in the grenade experiment the speed of the sound leads one to a figure for the temperature of the air, so in this experiment the speed of the radio waves leads to the number of electrons in unit volume. In other experiments, open-ended tubes at the front of the rocket will sweep up a sample of the ions in their path; at the same time a miniature mass spectrograph in the tube analyses them; alternatively the currents conveyed are measured, and from those measurements the ion concentration can be determined. In connexion with these experiments it is interesting to notice that the rocket is travelling much faster than the mean speed of the atoms and ions present, a situation quite the reverse of normal terrestrial experience and one that must be taken into account in the design and interpretation of the experiments.

One of the most remarkable discoveries made during the American rocket research work is the intensity of the day air glow. This luminescence in the upper atmosphere is stimulated by the solar radiation and may account for as much as 3% of the day sky light. At altitudes above 30 kilometres the blue sky is beneath the rocket. The sky above is dark, but for the stars and the air glow which is like a perpetual and ubiquitous aurora. This air glow is also present to a lesser extent at night.

At present very little is known about its spectral quality and variation with altitude. In order to arrive at an understanding of the origin of the air glow and the photochemical processes involved, observations are to be made using rocket-borne photoelectric photometers operating in a variety of spectral regions. Another mean of studying the processes operative in the air glow is artificially to increase the concentration of one of the components thought to be taking part in the reaction. This is the basis of the sodium experiment recently carried out in the U.S.A. and which may also form part of the British programme. The yellow D lines of sodium are prominent in the spectrum of the air glow although sodium is thought to be present in the atmosphere in only one part in a hundred million. The intensity of this part of the air glow spectrum is increased by a very large factor if sodium vapour is launched into the atmosphere at a suitable height. Technically this is not easy to do, but the results are quite spectacular. In addition to the information it gives about the air glow, the drifting trail of light provides an optical means of tracking high-altitude air currents.

These are some of the experiments which have been planned. They represent only a start. Some of the most serious gaps in our knowledge of the atmosphere concern the concentrations of rare constituents, particularly molecular compounds like the oxides of nitrogen, carbon and hydrogen. By a coincidence the announcement of the British programme occurred at the same time as that of the American plans for a satellite experiment during the International Geophysical Year. Whilst it is fortunate that British rockets will be available during that time of increased effort and integration of the research, the British programme is not limited to the Geophysical Year, but can be expected to continue for some time. There are many problems to be studied. Some will require a widespread use of rockets, probably from ships at sea, and many years of research.

THE MOST ACCURATE CUBE IN THE WORLD

A. G. THOMSON

Three Divisions of the National Physical Laboratory are collaborating in an attempt to measure the density of mercury to a higher degree of precision than has previously been achieved.

In the establishment of 100°C on the International Scale of Temperature, it is desirable that the error should be kept within 0·0001°C, since the melting-points of pure chemicals are sometimes expressed to this degree of precision. The temperature at which water boils varies with the pressure, and the degree of precision required in this region of the International Scale of Temperature makes it necessary for measurements of pressure to be accurate to about one part in 300,000. This in turn depends on the precision with which the density of mercury can be determined. Two procedures have been adopted for this purpose, and it is expected that they will give results accurate to about one part in 1 million.

One method utilises a 3½-inch solid cube of tungsten carbide sintered with cobalt. This weighs 22 pounds in air, and half a pound when totally immersed in mercury. The volume is found from measurements of the sides in terms of light-waves and the cube is then weighed in air and mercury. The difference between the two weights divided by the volume of the cube gives the density of the mercury.

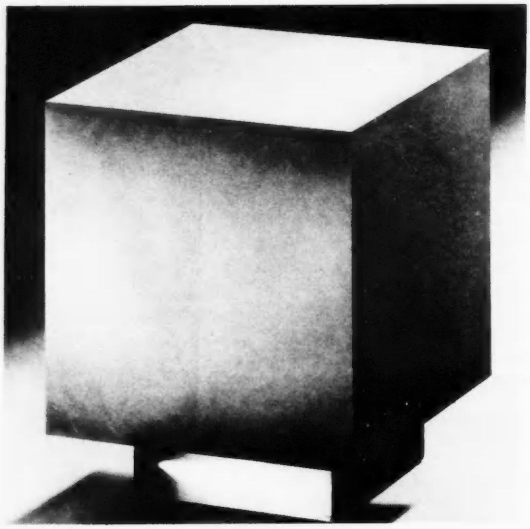
In the second method the weight of mercury contained by a 3-inch cubic box is determined.

All the initial machining of the solid tungsten carbide cube that was purchased by the NPL had been controlled to one-thousandth of an inch. An even higher order of accuracy was now called for, however, while further steps had to be taken to make the edges perfect and the surfaces absolutely flat and square. The cube was therefore subjected to a lapping process, for which two soft cast-iron plates charged with suitable grades of diamond powder were employed.

Because of its heavy weight the cube had to be very carefully handled during the lapping process. The most difficult requirement, however, was to keep the surfaces flat and at the same time ensure that parallelism and squareness to adjacent surfaces were preserved. The procedure adopted was to regard one surface as a datum and to control its flatness by testing it with an optical flat as the work progressed. The surface opposite to it was then made parallel, any errors being corrected by applying hand-pressure locally. Once two surfaces were flat and parallel, the adjoining surfaces could be made square to them. As the work proceeded Sellotape was used to protect the razor-sharp edges and the surfaces which were not being worked.

The finished cube was seen by the Duke of Edinburgh during a visit to the National Physical Laboratory. It had faces like mirrors, and edges that could cut your finger. The faces and edges were examined for local blemishes, but no fault was found that would affect the volume by as much as one part in 100 million.

Because each face is slightly depressed at the centre the volume of the cube is reduced by about six parts in a million. The cube was therefore inserted in a bath of medicinal paraffin so that its top face was slightly submerged. Variations of the distance between that face and the reference surface of the paraffin were measured by means of an interferometer. From the results a contour map of the top face was made with contours at intervals of one-millionth of an inch. The same



(*Above*) The $3\frac{1}{2}$-inch tungsten carbide cube. (*Left*) Contour map for one face of the cube; the contours are drawn at intervals of a millionth of an inch. Dots represent measurement points.

procedure was repeated for all the other faces of the cube. The lengths of the edges were determined by adopting an interferometric method used to measure engineers' block gauges; over a period of two and a half years no edge appears to have changed in length by more than one part in 10 million.

The lapped surfaces of the cube are covered with tiny hills and valleys, the tops of the hills being about *two-millionths of an inch* above the bottoms of the valleys. The volume of the valleys in the face of the cube has been measured. Here the method was to place a flat polished glass disk in optical contact with one of the surfaces, a minute, weighed, drop of paraffin having been inserted beneath it. As the drop is squeezed out it spreads, and the area the paraffin finally covers is measured. It was thus shown that the valleys occupy about one-millionth of the volume of the cube.

A "pneumatic-gauging" technique developed in the Metrology Division offered an alternative method of sizing the cube to the required order of accuracy. If compressed air at constant pressure is supplied through a fixed constriction to a jet placed near a surface, movement of the surface relative to the jet will alter the rate of escapement of air from the jet and so change the pressure between the jet and the constriction. By measuring the change of pressure the extent of movement of the surface can be determined. If two jets are held facing each other in U-shaped callipers just large enough to embrace the cube, the combined escapement from the jets will be governed by the thickness of the cube. The variations in thickness revealed by this method agreed very satisfactorily with those found by interferometry.

Weighing the cube in mercury presented a number of difficult problems, the first being how to suspend the cube from the balance. The solution finally adopted was to make a small block of heavy tungsten alloy that sinks in mercury. This block was chromium-plated and the bottom face was lapped flat so that it could be wrung into optical contact with the top face of the cube. A tungsten wire was passed through a ring in the top face and secured firmly. The block was separately weighed in mercury.

Although the wire is only two-thousandths of an inch in diameter, the pull of the mercury on it due to surface tension may vary by as much as 10 milligrams because the angle of contact mercury makes with solids is very variable. Observations showed that the effect was slightly different when the block was weighed without the cube. This factor had to be allowed for by making a small correction to the weight measurements, amounting to about two parts in 10 million.

Care had to be taken to ensure absolute cleanliness of both the mercury and the cube. To eliminate the error that could have arisen through bubbles sticking to the cube, a very low air pressure was maintained when pouring the mercury round the cube.

It is desirable that, while the cube is being weighed, the temperature of the mercury should be known to within 0·001 °C; a temperature difference of that amount affects the density to the extent of two parts in 10 million. For this reason the mercury container was heavily lagged with cork and kept in a constant temperature room.

Two hollow cubes for use in the second method have been produced in the Light Division. Each one is made of six plates of fused silica held together by "optical contact" (that is, the adhesion of optically flat polished surfaces without an air gap). All corners and edges on the inside of the cube are "razor-sharp". In order to achieve "optical contact" all faces and edges had to be worked to better than two millionths of an inch. The optical worker relies on a special interferometer for flatness testing which enables him to check the accuracy of his work during the final stages of polishing.

It is believed that the silica cubes have been made to acceptable limits, but measurements are still in progress. Preliminary mechanical measurements are being made on the inside dimensions of the cubes, and these will be followed by numerous optical measurements.

THE SEA AS A CHEMICAL STORE

J. GORDON COOK, Ph.D., F.R.I.C.

Every drop of rain that falls to earth is a little bomb that blasts away a tiny fragment of rock or soil. The physical disruption caused by each individual drop is infinitesimally small. But the cumulative effects of rainwater falling steadily and draining over the land for millions of years, are such that they have carried away huge quantities of minerals from the land into the sea. Sea-water has become a dilute solution containing most of the elements present in the earth's crust. It is a liquid mine that could provide us with supplies of many of the raw materials needed in our industrial world.

Although sea-water contains only a modest concentration of dissolved material—about 34·5 grams per kilogram—the total quantity is so large as to be almost beyond comprehension. It has been estimated that the salts in sea-water would cover the land surface of the earth with a layer about 500 feet thick.

Every cubic mile of sea-water contains more than 100 million tons of common salt, 4 million tons of magnesium and 1,800,000 tons of potassium. At the other end of the scale there are traces of many elements in such dilute solution that they cannot easily be estimated. It has been claimed, for example, that there are some 7 tons of uranium in a cubic mile of sea-water. If this estimate is correct, it means that in the 300 million cubic miles of sea-water forming the world's oceans there are more than 2000 million tons of this metal.

EARLY ANALYSES

The first comprehensive study of sea-water salts was carried out by Prof. W. Dittmar of Anderson's College, Glasgow, in 1884. He analysed seventy-seven specimens of sea-water brought from many parts of the world by the H.M.S. *Challenger* Expedition of 1873–6. He found that, although the total quantity of dissolved salts varied according to the source, the relative proportions of the salts in ocean water remained constant.

In the great water-basins of the Pacific, Atlantic and Indian Oceans, salinity is low near the Equator, where rain is so heavy that it overcomes the effect of evaporation. Farther north and south, the water tends to become saltier as evaporation becomes the predominant factor. Then, towards the poles, the water becomes fresher again.

Near areas of land-drainage the composition of sea-water is naturally affected by the influx of river water. The Baltic Sea, fed by the rains of north-west Europe, is sweeter than the Atlantic Ocean to which it is joined; the Dead Sea, on the other hand, trapped in a hot, parched region of the earth, is so concentrated that the salts are ready to crystallise from the water—its average salt content is about 30%.

The inexhaustible stores of minerals in sea-water have always been a challenge to the chemist. The sea has been providing us with common salt since the earliest days of recorded history. Yet it is only within the last thirty years that we have been using sea-water directly as a source of industrial raw materials other than salt.

CHESHIRE'S SALT-BEDS

The commercial importance of sea-water salt is often underestimated. In Britain, the United States, Germany and France, salt is mined from deposits left behind as ancient seas have evaporated. A good example is provided by the salt-beds of Cheshire, which have become the site of Britain's alkali industry. But in countries less fortunate, people have turned to the sea as their source of common salt. Wherever the sun and the wind provide the energy needed for evaporating water, salt can be obtained economically from the sea. India derives much of her salt from sea-water. Even in the U.S.A. sea-water salt is a thriving industry; in 1948 its output was 800,000 tons.

In the south of San Francisco Bay, high-grade salt is obtained from some of the most up-to-date salt-plants in the world. Sea-water is impounded in settling tanks covering hundreds of acres. After a preliminary evaporation which lasts about a fortnight, the sea-water is pumped into ponds where further evaporation takes place. Calcium sulphate and iron sulphide separate from the concentrated brine or "pickle". The pickle is then pumped to crystallising ponds; more water evaporates and the salt crystallises.

The main requirement in the successful production of salt from the sea is a source of cheap energy; nine-tenths of the water must be evaporated before salt will crystallise. In cold countries, where the sun does not provide the energy needed, sea-water is concentrated by freezing; pure water is removed as ice, leaving a concentrated salt solution behind. Salt is made in this way in Sweden and in Russia.

The survival of the ancient techniques for getting common salt from the sea, and their development into a modern industry, is a reflection of the universal importance of common salt to man. Ever since our ancestors learned to cook their food, man has had to provide himself with extra salt to replace that which was lost in cooking. The human body needs a proper ration of salt; and where the earth cannot provide it, man has had to extract it from the sea.

There has been no such compulsion to isolate other chemicals from sea-water. Most of the ores and minerals used in industry could be obtained more conveniently by digging them from the land surfaces of the earth. Why go to all the trouble and expense of extracting them from dilute solution in sea-water?

During the last twenty or thirty years, conditions have been changing. Rich sources of some of our essential raw materials are becoming more difficult to find.

Meanwhile, extraction techniques have developed, and we can remove materials from dilute solutions

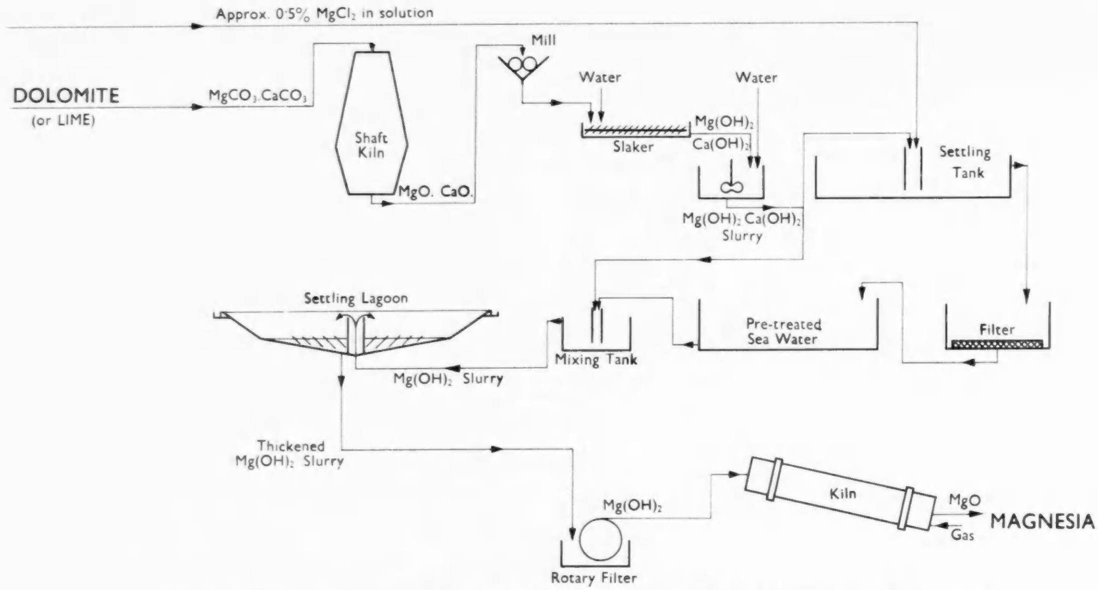


FIG. 1 Flow sheet of the process operated by the British Periclase Company for producing magnesia from sea-water. The magnesia from this plant is converted into chloride which is then electrolysed to yield magnesium metal.

much more expeditiously than we could a decade or two ago. The large-scale extraction of some of the dissolved substances from sea-water has become an economically attractive proposition. Already, there are two new important industries using sea-water as raw material, and others are preparing to follow.

BROMINE FROM SEA-WATER

During the 1920's, the development of anti-knock petrol brought with it a demand for bromine in unprecedented quantities. Bromine was needed for making the ethylene dibromide used with tetra-ethyl lead in anti-knock fluid.

Bromine is unusual in being essentially a maritime element. It occurs only to the extent of about 1% in the earth's solid crust; most of the world's bromine is in the sea. And it was to the sea that chemists turned for the supplies of bromine needed by the petroleum industry.

The first seawater-bromine factory was a floating one—the s.s. *Ethyl* extracted bromine from some 5000 gallons of sea-water a minute while cruising off the coast of North Carolina. By keeping on the move, the floating factory avoided taking in water that had already been processed. That was the idea behind carrying out the extraction at sea, but although the s.s. *Ethyl* obtained some bromine, the operating difficulties proved formidable, and the floating bromine factory made only one cruise.

In 1931, the Dow Chemical Company selected a seashore site for a bromine factory at Kuré Bay in North Carolina. The factory was built on a promontory; water could be taken from the sea on one side and expelled on the other side, where it was carried away by the prevailing current. There was thus no danger of re-treating water that had already been through the factory.

By 1933, this bromine factory was in full-scale production. It has since been enlarged and can now process 60,000 gallons of sea-water a minute and extracts 18,000 pounds of bromine a day. First of all, sulphuric acid is added to acidify the incoming sea-water to *p*H 3·5. The acidity of the water must be carefully controlled to prevent bromine being lost by hydrolysis, and to avoid waste of chlorine in the subsequent stage.

Treatment of the acidified sea-water with chlorine liberates the bromine from its salts. The bromine is blown out of solution, and in the original process it was converted to sodium bromide and sodium bromate by absorption in sodium carbonate, according to the following equation:

$$3Na_2CO_3 + 3Br_2 = 5NaBr + NaBrO_3 + 3CO_2.$$

This mixture of bromide and bromate was then heated with sulphuric acid to liberate free bromine.

The sodium carbonate absorption process has now been superseded by a process using sulphur dioxide. Bromine combines with sulphur dioxide and water to form sulphuric acid and hydrogen bromide,

$$SO_2 + Br_2 + 2H_2O = H_2SO_4 + 2HBr.$$

Bromine is then liberated from the hydrogen bromide by chlorine, and is blown out of solution.

During World War II, a bromine factory was built

at Hayle in Cornwall. Bromine was extracted from hot sea-water coming from the cooling system of a power plant. Since then the same company (Associated Ethyl Co. Ltd.) have built another bromine plant, at Amlwch on the Isle of Anglesey. Here 350,000 gallons of sea-water are treated every day, using a process essentially the same as that used in the U.S.

This establishment of bromine production was the first commercially successful attempt to "mine" the sea for a chemical other than salt. In 1921, the U.S. production of bromine was 711,953 lb.; by 1942, output had risen to 65 million pounds. Much of it came from the sea.

Bromine extraction provided experience which was invaluable in establishing a second great sea-water industry—the extraction of magnesium metal.

EXTRACTION OF MAGNESIUM

In 1939, magnesium was a comparatively expensive metal that was made in only modest amounts. During the war it came into its own. It was needed in quantity for making incendiary bombs. It played a very important part in the air war; the alloys of magnesium and aluminium have a strength comparable with that of steel but are very much lighter. Their production was essential for aircraft construction.

As the demand for magnesium increased, chemists turned once again to the sea. With 4 million tons of the metal in every cubic mile of sea-water, there could never be any shortage of raw material. With their experience of bromine production to help them, Dow Chemical Company designed a huge magnesium factory that was built on the sea-shore at Freeport, Texas. The first ingot of magnesium from the sea was cast there on January 21, 1941. This magnesium factory, like the bromine factory at Kuré Bay, was built on a promontory so that water discharged from the plant could be carried away from the inlet pipes. A second magnesium plant was built at Vilasco in Texas.

TABLE I

THE WEIGHTS OF THE DIFFERENT MINERAL SALTS DISSOLVED IN A CUBIC MILE OF SEA-WATER. (THEIR TOTAL WEIGHT IS APPROXIMATELY 166 MILLION TONS.)

	Tons
Sodium chloride	128,248,403
Magnesium chloride	17,946,522
Magnesium sulphate	7,816,053
Calcium sulphate	5,939,747
Potassium sulphate	4,068,255
Calcium carbonate	579,832
Magnesium bromide	358,270
Fluorine	1,374
Barium	916
Iodine	100–12,000
Arsenic	45–367
Rubidium	198
Silver	up to 45
Gold	23
Radium	5 grams

(from *Canadian Mining Journal*, 1931, vol. 52, p. 852.)

The process used in these U.S. plants begins with the conversion of the magnesium chloride in sea-water into magnesium hydroxide, which is precipitated from the water. The precipitate is allowed to settle and thicken, and after washing is converted into magnesium chloride by treatment with hydrochloric acid. The magnesium chloride is purified and electrolysed to release magnesium metal.

The main raw material used in this process, apart from the sea-water, is the lime used for converting magnesium chloride into the hydroxide. Once again the sea provided for the factory's needs; the lime needed for the factory was produced from oyster shells.

In Britain, magnesia is extracted from sea-water by British Periclase Co. Ltd., at a factory at Hartlepool, Co. Durham. Instead of using lime for precipitating the magnesium hydroxide, British Periclase Co. Ltd., use a mixture of magnesium and calcium hydroxides obtained by calcining and slaking dolomite ($MgCO_3$, $CaCO_3$). This has the advantage of doubling the return of magnesium hydroxide; half comes from the magnesium chloride of sea-water, and half from the magnesium of the dolomite.

In bromine and magnesium extraction, we have two major industries now established on the sea-shore. But they are making use of only two of the many potentially valuable substances in sea-water.

OTHER POSSIBILITIES

During the last war, British farmers could not get the potash needed as fertiliser for their crops. Supplies of potash from the Stassfurt mines were cut off, and we had to bring in potash from other sources overseas. Yet in the water on which our cargo ships were floating there are unlimited supplies of potash—more than 4 million tons in every cubic mile. In peace-time, there is no desperate need to develop these resources of potash in the sea. We can import our potash from the European mines or from the inland lake we call the Dead Sea. But there are signs that sea-water may yet become a source of potash on a major scale. It is reported that a full-scale potash plant will be built in Norway.

Copper is one of the most useful and important metals in our modern world. But some of the deposits of richer copper ores are running low. At some time in the future, perhaps before the end of the present century, we may be turning to the sea as a source of copper on an industrial scale. Judged by normal industrial standards, the concentration of copper in sea-water is extremely low—only 0·01 part per million. But modern techniques such as ion-exchange are enabling us to extract dissolved materials from solutions as dilute as that.

Human nature being what it is, man has always been fascinated by the prospect of persuading the sea to deliver up its enormous hoard of gold. There is no doubt that gold is present in sea-water, but estimates of the concentration appear to vary widely. It is probably safe to say that we could rely on getting many millions

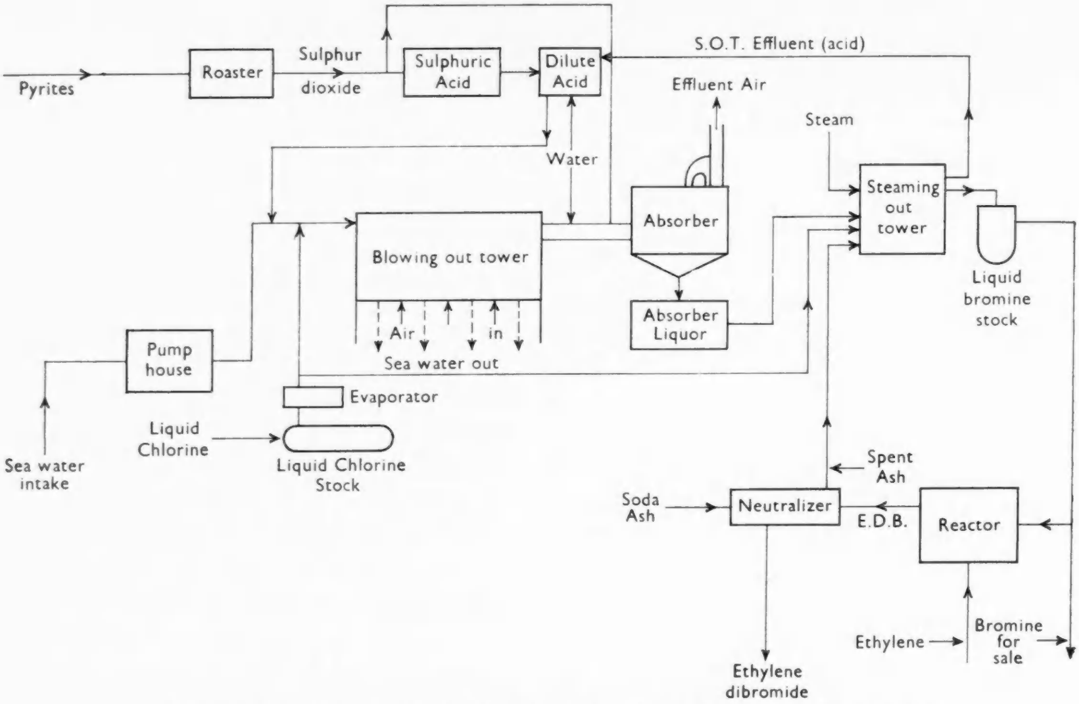


FIG. 2. FLOW SHEET FOR PREPARATION OF ETHYLENE DIBROMIDE FROM SEA-WATER. THIS PROCESS IS OPERATED AT THE AMLWCH PLANT OF THE ASSOCIATED ETHYL CO.

of pounds' worth of gold from every cubic mile. But nobody has yet devised a method of extracting it economically.

After World War I, the eminent German chemist Fritz Haber hoped to make use of sea-water gold in paying off his country's war debts. Haber's floating laboratory, the *Meteor*, cruised in the Atlantic, searching for the region where gold was at the highest concentration.

Haber discovered that the gold was not dissolved in sea-water; it was suspended as fine particles which were absorbed by micro-organisms and eventually carried to the ocean floor. The sediment covering the bed of the sea is often comparatively rich in gold. Haber found that the richest "gold-bearing" region of the Atlantic was near the Newfoundland coast. But even here, the concentration was too low to provide sufficient returns to pay for the cost of extraction, and he was forced to abandon his sea-water gold-mine. Since then, other attempts have been made to extract sea-water gold, but as yet, the sea has held on to its vast reserves of bullion.

It seems most likely that these minor but valuable constituents of sea-water will, in due course, be extracted as by-products from other sea-water industries. Gold has been stripped from the water passing through one of the U.S. bromine factories. But even under these conditions the yield of gold did not pay for the cost of its extraction; the project was abandoned after operating for a month.

As our experience of sea-water-processing increases we shall, no doubt, be able to cut down costs to the point where extraction of many valuable by-products becomes a commercial proposition. Chemical factories based on sea-water as their raw material will produce a range of products as varied as those which come from the synthetic fertiliser factories which now draw most of their raw material from the air.

READING LIST

E. F. Armstrong and L. M. Miall, *Raw Materials from the Sea*, Leicester, 1946.

H. U. Sverdrup, M. W. Johnson, R. H. Fleming, *The Oceans*, New York, 1942.

D. K. Tressler, *The Marine Products of Commerce*, New York, 1923.

The Royal Institute of Chemistry has recently published a 30-page booklet, price 4*s*. 6*d*., entitled *Chemical Aspects of Oceanography* by Dr. H. Barnes. This covers a number of aspects of "sea-water chemistry" including the industrial production of magnesium, bromine, etc. Figs. 1 & 2 are reproduced from this publication by permission of the Royal Institute of Chemistry.

COLUMBIUM'S CHEQUERED HISTORY

M. SCHOFIELD, M.A., B.Sc., F.R.I.C.

With the first production in Britain of ductile sheet and seamless tubes of the rare metal columbium, a new chapter has been opened on a strange story. This shining steel-grey metal resembles platinum in appearance and in high resistance to corrosion. According to some European chemists it should still be called by the older name "niobium".

The first name given to this element, which was discovered in 1801 by the English chemist, Charles Hatchett, was columbium. Hatchett coined the name after finding the metal in the mineral columbite. Yet when Heinrich Rose, the famous German pharmaceutical chemist, found a similar mineral in Bavaria, which contained columbium in addition to the sister element tantalum, he called it "niobium" from Niobe, the daughter of Tantalus and goddess of tears.

It was a descendant of John Winthrop the Younger, Governor of Connecticut, who sent to Britain the first specimen of columbite among a batch of mineral samples presented to the Royal Society. Sir Hans Sloane placed this historic specimen in the British Museum, labelled it "Number B.M.60309", and there it lay for decades before Hatchett studied it. This Charles Hatchett was the son of a prosperous coach-builder of Long Acre and a brilliant chemist, who would have achieved even greater eminence had he not been lost to what Thomas Thomson called "the baneful effects of wealth". Yet credit must be given to Hatchett for discovering columbium a year before tantalum was found. The English chemist did not actually isolate the element, and indeed a whole century was to elapse before such a separation materialised. Hatchett fused the columbite with potash, dissolved the residual melt, filtered off iron hydroxide, and then added nitric acid to the filtrate to bring down a heavy white precipitate. He realised that a new element was present, one which formed coloured precipitates of which two, an olive-green prussiate and an orange gallate, were suggested as future pigments by the practically minded Hatchett.

Only a year later in 1802 came the discovery of tantalum by Ekeberg, a professor at Uppsala. Ekeberg's "tantalite" ore from Finland, like Hatchett's columbite, contained both sister elements which were to prove inseparable for decades. The confusion over names thus dates back 150 years. Even today, although columbite is given the formula $(FeMn)O\,.\,(CbTa)_2O_4$, the mineral is called "tantalite" should tantalum happen to be in excess. By 1844 Heinrich Rose had proved some other element present in his Bavarian columbite; hence his "niobium".

After such a confused beginning the chemistry of columbium slowly developed with the emphasis on the efforts to prepare the pure metal. By 1864 C. W. Blomstrand prepared an impure steel-grey specimen by heating columbium chloride in hydrogen. Then came a halt until the beginning of the present century, when in 1901 the versatile Henri Moissan used his electric furnace to reduce columbium oxide with sugar charcoal. He thus obtained a small ingot of columbium, which, however, was not free of carbon; indeed it proved so inert and refractory that the French chemist imagined that perhaps some non-metal like silicon or boron was under observation.

Much nearer the target was the preparation by Werner von Bolton of the Siemens-Halske company of Berlin of a pure specimen of columbium. In this experiment of 1906 he made use of the high affinity of aluminium for oxygen at high temperatures in an "aluminothermy" process in which columbium oxide was reduced by aluminium powder. Von Bolton was ever searching for new metal filaments for the growing electric lamp industry. He had succeeded in making tantalum filaments by compressing retractable tantalum powder into rods, heating these in the electric arc, and then drawing such rods into filaments, all as a prelude to the "powder metallurgy" technique in which metals like columbium or tantalum are strongly compressed as powders, sintered and heated in vacuo or hydrogen, submitted to several hundred hammer-blows per minute, and thus rendered ductile for industrial use.

Columbium is now marketed in the form of sheet, wire, rod and tube. Intermediate between platinum, which dissolves in *aqua regia,* and tantalum which resists this powerful acid mixture, columbium dissolves slowly; hence there will never be columbium dishes and electrodes in the laboratory to give service comparable to that of equipment made of tantalum. Columbium, however, does not become brittle like tantalum when heated for short periods in air, the oxide film formed being of the "protective" kind. In its resistance towards atmospheric corrosion the metal is regarded as intermediate between tantalum (which remains untarnished after years of exposure) and tungsten.

Columbium seems destined to find application in high-vacuum electronic tubes, for it possesses "getter" properties having an affinity for traces of gaseous impurities left in such tubes, which is superior to that of tantalum. Like the carbides of tungsten, tantalum and titanium, columbium carbide is invaluable in machine-tools and in carbide dies for wire-drawing; moreover, when columbium carbide is added to tungsten carbide it imparts what is called a "self-lubricating" effect to the die during drawing operations. The new metal is proving useful (in additions of up to 1%) in stainless austenitic steels to prevent "weld decay". Although a Deptford firm has marketed a range of alloys containing columbium and aluminium, such developments of this exceptional metal are handicapped by its rarity and cost.

LETTERS TO THE EDITOR

SCIENTIFIC "ILLITERACY"

Sir:

Like many others I read with great interest the leader on Scientific "Illiteracy" in your December 1955 issue. One must admit regretfully that the charge is in general true with some notable exceptions. It is easy to see how the situation has arisen: the average scientific worker has never had much chance of becoming literate. He was early spotted as likely to get a science scholarship, or at least to do well in science, and his subsequent time at school was directed largely to furthering that end. Ability to write down in clear, crisp English what he was doing or hoped to do, or what somebody else had done, was not essential to his success and little time could be devoted to it.

The main purpose had to be achieved; other objects, however desirable in themselves, had to be put aside. Some of the pupils regretted it. A year or two ago I attended a debate at one of our University Agricultural Colleges on the proposition "That in the opinion of this House, the Universities are so busy teaching us that they have no time to educate us". The speeches were most illuminating: all the speakers recognised the need for the scientific and technical instruction they were getting, but most of them deplored their lack of time to familiarise themselves with our wonderful heritage of art, music and literature.

The problem is fairly recent. Almost any science in its early stages is easy, and can be studied single-handed with few and simple resources. Like prospectors in a virgin goldfield the first investigators find the nuggets on the surface: discoveries come readily. The pioneers of seventy or eighty years ago had done little or no science at school but went up to the University with a good literary training, often a classical training, which some continued after graduation. P. F. Frankland was said to be able to correct the "quantities" of the Professor of Latin at Birmingham; D'Arcy Thompson was regularly consulted by Stuart Jones, the Editor of Liddell and Scott's great Greek lexicon; H. B. Dixon and J. B. Farmer could quote aptly from the Latin classics; as a more recent example N. V. Sidgwick of Oxford took a First in Greats as well as in Natural Science. With such a background it was easy for these men to express themselves in that "appropriate, perspicuous, accurate, persuasive" English that Quiller-Couch enjoined on his students in his fascinating lectures on *The Art of Writing* —a book which, with its companion, *The Art of Reading*, should be closely studied by all scientific workers who aspire to leadership. These pioneers had the further advantage that their subjects were still in the stage when great sweeping generalisations, majestically broad and simple, seemed to be unshakeably established.

But science has moved fast and far since then. Its old simplicity has gone, it is no longer on the fringe of the ordinary man's experience but in new regions, dealing with concepts and things so remote from daily life that our ordinary words cannot express them; new words or symbols have to be devised. By common consent Greek or Latin syllables are used in making up the words, and as few people know either language they are unlikely to be misled by the result or shocked by an occasional barbarous monstrosity. A few of these words become familiar by frequent use, though without being understood, but most of them do not, and a sentence containing two or three of them is apt to be branded as jargon.

The fact is that our finite minds are grappling with Nature which is infinite: even the smallest natural object is utterly beyond our comprehension. The effort is asymptotic as Browning long ago pointed out ("still to its asymptote speedeth the curve"). No one can attain the entire truth: one man's deductions can always be called in question by another, dogmatism is completely ruled out and any statement may always have to be conditioned by reservations. This of course explains much of the diffuseness of which complaint is so often made.

All the same, much of the present bad writing is due to lack of thought and could be remedied. I am at present writing a book on Soil for non-technical readers and trying to include results contained in some of the thousands of scientific papers that have been published on the subject in recent years. But I find it difficult. When I have extracted what I think is the meaning I am apt to find on reference to the authors that it is not at all what they had meant to convey—not infrequently it transpires that they neither meant what they wrote, nor wrote what they meant.

There is, however, no cause for despair. Ordinary scientific papers may be likened to bricks which have little intrinsic interest till some great architect comes along and evolves order out of the chaos: from the jumbled pile of bricks a stately edifice is erected. These great architects have not only a clear vision but the power to describe it well: men like Rutherford, Ramsey, Bragg, Bateson, to mention only a few. This art can be cultivated even by those who cannot aspire to great leadership: they can still learn to tell their fellows what they are doing and what they have been able to read in "Nature's infinite book of secrecy". My advice to all young scientific workers is this. Directly you have got your B.Sc. out of the way devote an hour a day to reading good English literature and try to memorise any phrases that appeal to you. Before writing your paper think out fully what you want to say, and then put it down in the clearest English you can command. Read it over, cut out any unnecessary words and shorten any awkward sentences. Remember always the advice given by Francis Darwin to one of his students when handing back an essay for which he had asked: "You would be surprised how much it would improve your style, Mr. X, if you left out every other word." The student took it to heart, became a notable leader in his subject, and an able writer of lucid and pleasing English.

E. JOHN RUSSELL.

Woodstock,
Oxon.

Sir:

The remarks in your leading article on Scientific "Illiteracy" in the December DISCOVERY are unfortunately only too true. Cause and cure both call for careful study. The cause, I feel sure, is not that people are becoming more illiterate than they once were. Quite the reverse. The true reason why this scientific "illiteracy", as you so aptly describe it, has become an acute problem is that the need for the presentation of technical information (abbreviated to PTI) has increased recently and with disconcerting suddenness. To appreciate this one need only compare the beginning of this century with the present day in such matters as number of scientific societies and institutions for special branches of technology, number of specialised periodicals, number of conferences on technological subjects both national and international, number of hours that the technologist has to spend in committee, quantity of paper that passes from room to room in every large organisation. Reports, minutes of meetings, instruction sheets of all kinds, as well as technical books and papers, claim a substantial portion of the time of every technologist. Talk and paper have indeed come to be among the major tools of production in modern industry. I dare not hazard a guess as to the multiplication factor that would have to be applied to the daily output of technical information fifty years ago in order to reach the present high figure.

The reasons for this prodigious increase in the importance of PTI are various. All branches of technology have become vastly more complicated

than they once were. The fragmentation of science goes on and on. Industrial units increase in size and complexity. In consequence, few jobs can nowadays be completed without the collaboration of a large number of workers. These have different kinds of specialised knowledge, different degrees of education, different backgrounds and interests. Yet they must communicate comprehensively with each other. Hence the great volume of technical information that must continuously flow from mind to mind.

This new situation has caught us unprepared. But it is no good to complain and leave matters there. If the volume of technical information does not flow efficiently we must do something about it. We should regard the problem of conveying technical information from mind to mind as a new industrial requirement arising out of a new situation in the same way as we regard the need for telephones or for harnessing nuclear energy. In other words, PTI must be recognised as an intellectual discipline on the same level as others. And to be advanced by similar methods.

When the need for treating a subject as a new discipline is appreciated, this subject acquires three things: a literature of its own, its own learned society, recognition in the universities by the establishment of lecturerships, readerships and eventually chairs. PTI has just begun to acquire all of these things. There is some literature, though it is disappointingly meagre. There are two PTI Discussion Groups, of which one meets regularly in London, the other in the Midlands; in these those concerned with the subject can meet and express their views as in other learned societies. The subject is also taught in sundry universities and technical colleges, most thoroughly in University College, London, where the teaching is both at undergraduate and at post-graduate level. At the present time the lecturer there, Mr. B. C. Brookes, is giving an advanced course to a selected group of senior people who wish to become part-time teachers in the subject. So something is being done, even though it is not nearly enough yet.

Yours faithfully,

REGINALD O. KAPP.

(Prof. Kapp treated many aspects of this subject in his well-known book *The Presentation of Technical Information*, which was published by Constable in 1948. For readers who wish to contact either of the two PTI Discussion Groups mentioned above, the relevant addresses are as follows—*London PTI Group*, Hon. Secretary, B. C. Brookes, University College, Gower Street, London, W.C.1; *Midland Group*, Hon. Secretary, P. D. Patterson, Dunlop Research Centre, Fort Dunlop, Birmingham, 24. Applications for memmbership of the Midland Group should be sent to Mr. H. P. Compton, Department of Industrial Administration, College of Technology, Gosta Green, Birmingham, 4.)

Sir:

I was glad to see you strike a blow, in your December issue, for the advancement of decent standards of English.

Scientists of today complain that too much of their time is sacrificed to perusing the literature. Some organisations are actually said to be running special courses designed to help their men improve the speed and efficiency of their reading. If the modern scientist is, however, knee-deep in printed matter, no one is more to blame than he. Anything he puts down on paper—even the simplest proposition—is rendered complicated by the use of stylised forms and phrases ("technicalese", if you like), while his prolixity makes him the despair of any editor. How men, who like to regard themselves as masters of clear and simple thinking, can contrive to be so labyrinthine in their written effusions, passes the understanding of ordinary mortals.

The importance of lucid expression was recently underlined by no less a person than Sir Alexander Fleck, Chairman of ICI. "It always distresses me", he said, "to meet otherwise competent scientists, many of whose ideas do not come to fruition simply because they cannot explain them properly to their less technical colleagues. Speaking as an industrialist, I prefer literate technologists to illiterate ones, even though the illiterate may have more technical knowledge."

It is certainly much to be hoped that more attention will in future be given to the cultivation of a good English style. Apart from simplifying communication between scientists, it is vitally necessary if Science is to do the job of explaining itself to a public that is growing more and more curious about Science's activities. At the moment, it is safe to say that, with half a dozen outstanding exceptions, the men who can be the spokesmen of Science, able to explain matters to workers in other fields than their own, have yet to emerge. It is important that they should, if only to ensure that a perplexed, and at times uneasy, public is to be disabused of the notion that the "boys" are sometimes using the "backrooms" as the venue for Black Masses.

GAMMA RAY.

(We much prefer to publish letters that are signed, but on occasions there are good and sufficient reasons for accepting a letter that has to appear above a pseudonym. In this instance we considered our correspondent's request not to use his name was thoroughly justified. But our preference for signed letters in the correspondence column remains—EDITOR.)

Only two days before his death on January 5, we received from Dr. F. Sherwood Taylor the following letter replying to the critique of his book An "Illustrated History of Science", which appeared in the January issue of DISCOVERY.

Sir:

Drs. A. N. and N. L. Clow, in their review of my Illustrated History of Science, have reasonably questioned the authenticity and status of the numerous new illustrations with which it is adorned, and which for the most part purport to picture events and persons of which no complete representations have survived. Such pictures are not meant to be used as sources but can be the means of transmitting from writer to reader a mass of true information bound together and given life by the imagination of the artist.

Consider what commonly has to be done in order to make such a picture. The author and artist read and discuss the subject, go to see any surviving apparatus, compare contemporary illustrations, views, portraits and surviving buildings, and so arrive at a real synthesis of a former scene. Rough drawings are exchanged, and by the time these have been corrected a great many new points will have had to be raised and solved, and the amount of information finally incorporated in the finished drawing may be very considerable. Such a method must of course depend on the good faith and knowledge of author and artist, whose first intentions must be to spare no pains to get at the most probable story.

I can only say that A. R. Thomson and I have got as near it as we could. We confess to having had a lark now and again: why should science alone be unsunned by any ray of humour? One or two pictures, like that of "Roger Bacon and the Cracker" or "The Descent of Man", are no more than a lark and the reader is told so. Others temper valuable information with a chuckle or a wink: others cast an eye on a human frailty, whether past or present, while some are affectionate portrayals of great men and women. They are, I think, good-humoured illustrations which contain a great deal of original work, some of it not to be found elsewhere and which it would take many pages to explain.

I am deeply convinced of the need for a new way of representing the history of science. To the rising generation the perspective technique of the pre-Renaissance period has become incongruous or repellent. They want to see the events of the growth of science beautifully drawn but in a fully intelligible convention. Meanwhile the contemporary illustrations of scientific experiments from the 16th to the 19th century are also becoming insufficient. The books of the 17th century and later give us generally no more than woodcuts and engravings, often to impossible scales. The laboratory

backgrounds of these pictures tend to be omitted, conventionalised, or replaced by labelled rows of vessels and implements on shelves, which afford a useful catalogue, invaluable evidence, but not a picture. In the mid-19th century, the nadir of dullness and bad printing is reached. Accordingly we have tried to redraw all this and in doing so have taken the opportunity to restore the human, humorous and lovely and true to the history of science. Whether we have succeeded in this respect can only be settled by the reader's judgment. Your reviewers, however, have given us little assistance in their comments on four of the new productions in particular. Who would think there were seventy-five or so original drawings on which so much labour and skill have been lavished? Their tone is contemptuous, and their criticisms are really irrelevant. What does the proportion of conjectural background matter, where a small object such as a clock appears in the setting that explains its existence? The Egyptian time-pieces are correctly drawn from casts of the originals: the ladies' dresses are taken from authentic sources: I'm afraid that Shaftesbury Avenue is not one of them. The picture of John Knox is made from a portrait reasonably thought to be as authentic as any, and great trouble was taken to ascertain that the St. Andrew's pulpit there figured comes as near as might be to its former appearance. Much of his preaching remains to us and if we do not find it lacking in vigour and vulgarity, we do not accuse it of "raving lunacy".

What we would ask is not that the occasional errors of our pictures should be spared—far from it, but rather that the extent and value of these original compositions should be recognised.

To return to the other criticisms of Drs. Clow, the author would not attempt to deny that throughout the book circumstances have forced him to try to find room for a quart in a pint-pot and consequently to select material which allowed of the development of the subjects best suited to his own resources and those of the Royal Institution.

I confess a few errors which should have been eliminated. The proofs have been corrected under the hand of illness and the author can only hope that another edition may afford a remedy for a few omissions and errors.

Yours sincerely,
F. SHERWOOD TAYLOR.

Crowthorne,
Berks.

Sir:

One can use coloured pencils and appropriate spectacles to produce diagrams having a 3-dimensional appearance. Would this not be useful for the "construction" of atomic and molecular models?

I have demonstrated to my own satisfaction that the 3-D effect can be so produced, but I lack the mental equipment to carry it further. Perhaps other of your readers may like to try their hands at it?

Yours faithfully,
J. C. WILLIAMS.

203 Albany Street,
London, N.W.1.

THE BOOKSHELF

Technical Education—Its Aims, Organisation and Future Development

By P. F. R. Venables (*London, Bell, 1955, 645 pp., 42s.*)

During recent years there have been numerous reports and publications on the subject of technical education. Committees set up by the Government, professional institutions, learned societies, trade unions, industrial and commercial associations, the Ministry of Education—all of these and many other bodies and individuals have had their say, and have emphasised different aspects of the subject. The conclusions and recommendations have varied with the points of view, and sometimes they have shown limited knowledge of existing facilities. There are so many different interests connected with technical education that it is extremely difficult to get objective opinions. Central and local government, universities, professional societies, industry, workers, large and small technical colleges, all have vested interests. In this book Dr. Venables has attempted to review the whole field and to make a critical survey of the many other views that have been expressed. As the principal of one of the larger technical colleges he too has a vested interest. However, he has the great advantage of knowing the subject intimately and at first hand. At the same time the point of view of the major technical colleges as seen from within must be given full consideration in the formulation of policy, and an authoritative statement such as is given in this book is therefore to be welcomed.

Not only has Dr. Venables discussed some of the controversial issues of the future policy for technical education, but he has also provided a vast store of information on almost every conceivable detail of the subject and everything associated with it. Indeed, in some respects, the book might more aptly be said to cover further education in general, since it deals in some detail with subjects like art, commerce and county colleges, and makes some reference to such subjects as nursing, home-making and courses for engaged couples. There is very full information on types of technical colleges and their courses, numbers of students (full-time, part-time day and evening), schemes for National Certificates and Diplomas, sandwich courses, relationships with industry, professional institutions, City and Guilds of London Institute, examining unions, national and regional advisory councils, financial arrangements and administration, etc., etc. There are about a hundred diagrams, tables and histograms giving full statistical details up to the end of 1953. Policy decisions are given up to 1955; indeed some are dated later than the preface. No pains have been spared by Dr. Venables and his contributors* to provide complete and up-to-date information, which will appeal to teachers, administrators and industrialists, indeed to anyone interested in technical education. One cannot help feeling that the book would make a stronger appeal if it contained less information. In some respects it suffers from, and emphasises, the dissipation of the efforts of technical colleges in Great Britain today. Many extraneous activities go on even in some of the major colleges and presumably Dr. Venables felt obliged to give particulars of these activities if he were to supply a true account.

Much of the factual information in the tables and diagrams is of considerable interest and is not readily available elsewhere in such a convenient form. Occasionally, the author's enthusiasm for diagrams gets slightly out of hand. It is difficult to see the point of diagram 5, p. 74. Again, in an interesting section on wastage in National Certificate courses, purely hypothetical tables seem to be introduced in order to point out the somewhat obvious conclusion that more passes would be gained if only the students were better selected. Incidentally, surely there is something wrong with the scale in diagram 13, p. 125.

This book, with its facts and statistics, will prove to be a useful reference work. The extensive index and numerous references at the end of each chapter will facilitate this use. It will also be read as a clear statement of the problems of technical education from the point of view of the larger colleges. It contains much shrewd comment not only on education but on

* Five out of the book's twenty chapters are contributed by specialists: Engineering (C. L. Old), Building (D. A. G. Reid), Art (K. Holmes), Women in Further Education (Miss E. Hollings) and Commerce (E. Thompson).

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industrial relations and social influences. Occasionally there are lapses in clarity, but in general the book is written in a lucid, stimulating and scholarly manner.

M. R. GAVIN

The Foreseeable Future

By Sir George Thomson (*London, Cambridge University Press, 1955, 166 pp., 10s. 6d.*)

It is proverbially much harder to forecast what the world will be like and what man will be up to in fifty or a hundred years' time than in two thousand. Sir George Thomson attempts the harder task. Readers of DISCOVERY will have already found out what Sir George thinks of the possibilities of space travel, for the chapter of the book dealing with this was printed in the October 1955 issue.

There is a note of restrained optimism. As Sir George sees it, the future is reasonably bright. He assumes, naturally, that there will be no disastrous wars.

The Foreseeable Future starts, as it must, from what is now known about the world's resources of energy and materials, the present state of physics, biology, engineering, and so on. For a quick appraising look at what mankind has already achieved, the book could hardly be bettered. As Sir George goes on to speculate about the future he tries to provide some idea of what he thinks the shape of the whole wood will look like as well as giving his views about some of the particular trees in it.

Sir George sticks rigidly to the non-sensational points of progress. This is possibly the best way to write about the foreseeable future, but sometimes the flatness of the resulting picture becomes anti-climatic. Sir George allows no flavour of personality to obtrude, except in the very first pages and two or three times elsewhere, which seems a pity in a book of this genre.

The Moon Puzzle

By N. O. Bergquist (*London, Sidgwick & Jackson, 1954, 378 pp., 16s.*)

Mr. Bergquist with great enthusiasm but with becoming modesty propounds the following novel thesis on the formation of the Moon. About 60 million years ago, when its crust had already solidified and was populated by mammals, the earth suffered a glancing collision with a large minor planet. This ploughed a furrow in the earth's crust and produced a ridge or bulge; it also twisted the crust into a spiral form, altered the tilt of the earth's axis and greatly increased its rate of rotation, with consequent flooding by the seas. As a result of the rapid rotation a large portion of the damaged crust and some molten magma were later shot off from the earth and became our moon. In the early stages material kept dropping back to earth from the moon, and for a very long time afterwards the earth regained its shape by intermittent convulsive movements accompanied by floods.

With this hypothesis the author explains a great many apparently unrelated phenomena in the fields of geography, palaeontology and above all geology. A large part of the book is given over to detailed consideration of geological problems, requiring more than a superficial knowledge of geology on the part of the reader. But the fact that the theory can explain various phenomena does not necessarily prove it is true.

The author invites discussion and criticism of his theory. Some of it should be amenable to mathematical tests and one would have liked to see more quotation of mathematical results in the text. A serious objection, mentioned by the author himself, is that a collision of any magnitude would generate enough energy to melt the earth. To counter this objection the collision is imagined as being a grazing one with the minor planet moving in the same direction as the earth's surface. It is doubtful whether this could impart enough energy to increase the earth's speed of rotation by a factor of four or five, and the whole theory would seem to fall to the ground. A calculation should also be made of the possibility of escape of the minor planet from the earth's gravitational field after the collision.

Mr. Bergquist is clearly no astronomer or he would not contrast the accuracy with which the rate of rotation of the earth can now be measured with the relative inaccuracy of eclipse predictions. The errors in the latter are due to lack of precise knowledge of the motion of the moon, and not to doubt about the change of rate of rotation of the earth.

The simple drawings which illustrate and explain the text are exemplary, and the book is well worth reading for the stimulating ideas it contains, even if the reader is only stimulated to disagree.

H. R. CALVERT

New Methods in Analytical Chemistry

By Ronald Belcher and Cecil L. Wilson (*London, Chapman & Hall, 1955, 287 pp., 30s.*)

This book relates to the developments which have taken place in classical or non-instrumental methods of analysis during the period from 1932 to date.

It is particularly addressed to practising analysts and research workers, but could with advantage be studied by Honours students in chemistry. It is designed to assist chemists in keeping abreast of the rapidly growing literature of the subject and to give opportunities for these techniques to be tried out more extensively than at present.

Some of the methods have been described by the authors in lectures under the auspices of the Royal Institute of Chemistry and have been reported in the Journal of the Institute, but very few have yet been incorporated in any standard work.

The text contains sections devoted to new methods involving precipitation, liquid-liquid extraction and titrimetry. There is also an extensive section on indicators and a large miscellaneous section which includes methods ranging from a titrimetry-precipitation method for the estimation of Silicon to the use of ferrous ethylene diamine sulphate as a primary ferrous standard for the titration of oxidising agents.

Each section has its own list of references, and a Subject and Author Index is included. The second reference on p. 2 should read: Anal. Chem. *1952*. 24, 459, not *1953* as printed.

Although this work does not claim to be exhaustive it gives a representative selection of the latest methods and should prove a valuable addition to the working library at a modest price.

D. S. H.

The Equatorie of the Planetis

A manuscript treatise ascribed to Chaucer, edited by D. J. Price (*London, Cambridge University Press, 1955, 214 pp., 52s. 6d.*)

Chaucer's *Treatise on the Astrolabe*, written in 1391 for the instruction of his ten-year-old son "litel Lowis", has long been known, proving that Geoffrey Chaucer, like so many literary giants of the past, was a man of parts actively concerned with both the affairs and the learning of his time. Recently a 14th-century manuscript in the library of Peterhouse, Cambridge, has been examined by Dr. D. J. Price, I.C.I. Fellow in the History of Science at Christ's College, who believes it to be in the handwriting of Chaucer. This assignment of its origin is the result of painstaking research and careful deduction, since a catalogue of the library compiled in 1589 attributes the authorship to Simon Bredon, an astronomer of Merton College, Oxford, who died in 1372—about twenty years before the date of the present manuscript, which describes an instrument, the *equatorium planetarum* or "equatorie", made in 1392. It seems probable that Bredon's work was a Latin translation of some Arabic text, and that what we have here is an English version of that translation. Its Eastern derivation is evident from the opening words: "In the name of God, pitiful and merciful."

Whereas the astrolabe was a device for calculating, on the basis of the Ptolemaic system, the apparent positions in the heavens of the sun and stars, the equatorium or equatorie was a more elaborate instrument for use in connexion with the planets. Many examples of the astrolabe have survived because their relative simplicity allowed of their being so embellished as to constitute fine specimens of the metal-worker's art, for which reason they tended to be preserved. But the equatorium was too complicated to admit of much decoration, and therefore was not cherished by

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edited by J. B. CRAGG and N. W. PIRIE, F.R.S.

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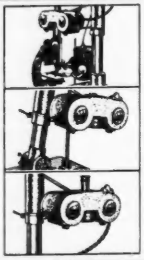

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New Books

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Edited by D. K. McE. KEVAN, B.Sc., A.I.C.T.A.,
Dept. of Agricultural Sciences, University of Nottingham.

This book contains the papers read at the Second Easter School in Agricultural Science organised by the University of Nottingham School of Agriculture, together with a full account of the techniques demonstrated. The purpose of the school was to provide a forum for discussion among specialists in soil zoology and to provide tuition, both theoretical and practical, for those who are now working in the field but who have hitherto received no specialist training.

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collectors; only two incomplete models are known to exist. A photograph of one of them, at Merton College, forms the frontispiece of this book.

The manuscript is unusual, for a medieval work on astronomy, in being written in Middle English instead of in Latin. We are given here a complete facsimile of the text interleaved with a line-by-line transcription, followed by a translation into modern English. There are also reproductions and modernised versions of some of the astronomical tables which accompany the text and form the bulk of the work, while Chapters VII and VIII are devoted to a detailed explanation by Dr. Price of the Ptolemaic Planetary System and to a history of the Planetary Equatorium. A linguistic analysis and glossary by Mr. R. M. Wilson of Sheffield University increases the value of the book to the reader unskilled in palaeography.

E. N. PARKER

Titanium

By A. D. McQuillan and M. K. McQuillan (*London, Butterworth's Scientific Publications, 1956, 466 pp., 56s.*)

This is the fourth volume of a series on the metallurgy of the rarer metals, previous volumes having dealt with chromium, zirconium and manganese. Dr. and Mrs. McQuillan have themselves made notable contributions to the metallurgy of titanium and its alloys, and their book will be widely welcomed as a readable and critical presentation of the information that has become available in this new field during the last few years.

Pure titanium was first obtained by Dutch workers in 1925. Recognition of the exceptional mechanical properties of the metal and its alloys has led to the establishment of large-scale production processes based on the reduction of titanium tetrachloride with magnesium or sodium.

Titanium is being specified, because of its high strength/weight ratio, for an increasing number of duties in military and civil aircraft (e.g. for the compressor blades of jet engines) and it is expected that its excellent resistance to corrosion and erosion in sea-water will lead to marine applications.

The present book will be of great value to metallurgists concerned with titanium problems. The importance of the transformation from the hexagonal α form to the cubic β form is stressed throughout the book. A long chapter on the constitution of titanium alloys includes an account of new techniques which have been developed for determining phase boundaries and liquidus and solidus lines in titanium systems.

The less specialised reader will find much to interest him in the description of the methods of production of titanium metal and the techniques used for casting the metal into ingots and subsequent fabrication. A property of titanium which complicates its technology is its reactivity at high temperatures towards oxygen, nitrogen, hydrogen and all refractories. This has led to the adoption of high-temperature vacuum techniques for the production of the metal and for ingot casting, the refractory problem being usually solved by arc melting the metal in a water-cooled copper crucible. Argon and helium are extensively used to provide protective atmospheres during the production of the raw titanium and while the metal is being melted or welded.

The book takes into account work published up to the beginning of 1955. It is well illustrated and has a good subject index.

R. B. MOONEY

Organic Chemistry

By Julius Schmidt (Edited by Neil Campbell). (*London & Edinburgh, Oliver & Boyd, 7th edn., 1955, 936 pp., 35s.*)

This edition of Schmidt has not only been revised but enlarged since the appearance of the last edition four years ago. The additions are in the sections on tannins, terpenes, carbohydrates, steroids and proteins and in the treatment of aromatic substitution. Though essentially a textbook for honours chemistry students, it is the best value at the price to anyone who needs some reference book in organic chemistry.

F. E. W.

TRANSLATION BY MACHINERY

M. V. WILKES, M.A., Ph.D.

Interest in the possibilities of mechanical translation is growing. Readers will remember the article on this subject by Dr. A. D. Booth, Director of the Birkbeck College Computation Laboratory, which appeared in the July 1954 issue of DISCOVERY. *Now, Dr. Booth, jointly with Dr. William N. Locke (who is head of the Department of Modern Languages of the Massachusetts Institute of Technology), has edited a volume containing contributions from a number of active workers in the field.* The author of this review article is the Director of the University Mathematical Laboratory at Cambridge.*

The idea of mechanical translation is not new, but only as a result of post-war developments in digital computers has it been possible to contemplate its practical realisation. The book opens with an account of discussions which took place between the Editors, Dr. Warren Weaver and others and led to the holding of a small conference at the Massachusetts Institute of Technology in the spring of 1946. As later chapters show, this subject is still in the stage of discussion and experiment, and no full-scale mechanical translation system has yet been demonstrated.

Although digital computers were developed primarily for performing arithmetic calculations they can do more than merely calculate; they can also store, sort, and collate information. They can discriminate between two possibilities and act accordingly, provided that the criterion of discrimination can be specified without ambiguity.

Data-processing Machines

Digital computers that have been specially designed for handling large quantities of information are best described as *data-processing machines.* Such a machine must be able to take in raw data and put out processed data at high speed. It must also be able to handle conveniently alphabetical characters as well as figures. More important still, the machine must be capable of storing data in large quantity, and at the present time this implies the use of magnetic tape similar to that used in a tape recorder for speech and music.

The primary purpose for which these machines are intended is the mechanisation of office procedures. They lend themselves, however, very well to experiments in translation from one language to another. Here the original text constitutes the input, the magnetic tapes hold a dictionary and a grammar, and the translated text is the output. One of the articles in this book contains an account of a somewhat crude demonstration of automatic translation using an I.B.M. (type 701) data-processing machine.

The Qualities of Mechanical Translation

The two interesting questions to discuss are: "How good can a mechanical translation be?" and "Would it be of any practical value?" No one would expect a perfectly idiomatic and

* *Machine Translation of Languages*, edited by William N. Locke and A. Donald Booth; published jointly by the Technology Press of M.I.T. and John Wiley, New York: published in Britain by Chapman & Hall, London, price 48s.

accurate translation from a machine; indeed it is very hard for a human being to produce such a translation unless he has been brought up to be bilingual from childhood and, even then, there can be room for debate about the accuracy with which shades of meaning in the original text are rendered. It is a first principle of automation that a machine cannot be made to do anything which cannot be reduced to precise rules, and the grammar and idiom of a language cannot be so reduced as regards their finer points. It therefore seems clear that there can be little future for machines in "literary translation".

As regards technical translation the situation is, however, somewhat different. Technical writing is, or should be, direct and to the point. What a scientist or engineer first wants to know when confronted with a paper in a foreign language is whether the paper treats of a subject within his range of interest; if it does, he then wants to know what information it contains. The form in which he receives that information is of minor importance. In this field machine translations seem to have a future.

Dr. Warren Weaver puts the matter well in his foreword to the book. After describing the effort which is being devoted to mechanical translation, he says, "This, in fact, is the reasonable purpose of this effort. Not to charm or delight, not to contribute to elegance or beauty; but to be of wide service in the work-a-day task of making available the essential content of documents in languages which are foreign to the reader."

On the whole scientists make little use of the services of professional translators, preferring instead to work with the original text and such knowledge of the language as they can acquire. No doubt economic considerations have tended to restrict the use made by scientists of professional translators, but another factor has, I think, been of at least equal importance. This is the fact that the professional translator, while he knows the language, is usually ignorant of the subject, and this handicap may be quite as grave as that of possessing only a rudimentary knowledge of the language. In the past French and German have been by far the most important languages with which an English-speaking scientist has been called on to deal, and most scientists have found little difficulty with them. If Russian becomes a major scientific language, it is likely that a great deal more formal translation will be necessary, and it is possible that some of it may be done by machines.

The simplest way in which a machine could help a scientist to understand a paper written in a strange language would be to act as an automatic dictionary, that is, to replace each word in the original text by a list of alternative meanings extracted from a dictionary stored on the magnetic tape. A variety of different tapes could be available, each one containing a dictionary appropriate to a different scientific field. Such a version—it can hardly be called a translation—is very much more useful to a person acquainted with the subject than might at first be thought. This is well brought out in a contribution by Mr. R. H. Richens and Dr. Booth on "Some methods of mechanised translation" and also in a contribution by Dr. A. G. Oettinger on "The design of an automatic Russian-English technical dictionary". Dr. Oettinger, working in the Computation Laboratory of Harvard University, was able to show, in the case of Russian, that, even if the grammatical information contained in the endings of nouns is ignored and if verbs are given in the infinitive form, it is possible for a person acquainted with the subject to discover the meaning of the text, although at the cost of some labour. The text Dr. Oettinger chose for his demonstration was connected with an application of Boolean algebra, and would have made very little sense to anyone ignorant of that particular field, however well he knew the Russian language.

The automatic dictionary is well within the range of practicability using existing data-processing machines. The versions produced by it, however, require far too much puzzling out by the user for the scheme ever to be a large-scale success. An improvement could be made by preserving and presenting to the reader the grammatical information—or a proportion of that information—contained in the word endings and in the word order. Serious progress in this direction requires that languages should be studied afresh from the point of view of a machine. Not only must the grammar and syntax be codified, but it must be codified in a selective manner, having regard both to the importance (from the point of view of the preservation of meaning) of any particular rule and to the frequency of application of that rule. To include every conceivable statement which could be made about the language would not only overload the storage of the machine, but would slow down the process of translation. The task is immense, and the later contributions in the book are to be regarded as progress reports from workers who are devoting serious attention to it. They will perhaps be of more interest to the general reader for the indication they give of the kind of study of language which is necessary in the present connexion rather than for the results achieved.

If necessary, a suitably qualified person could turn the version produced by the machine into a correct translation into standard English. In the jargon of mechanical translation such a person is termed a *post-editor*. He must be familiar with the subject, but need not be familiar with the original language. At one time it was suggested that there should also be a *pre-editor*; he would be familiar with the language but not with the subject, and would prepare the text for the machine. Informed opinion now tends to regard the pre-editor as unnecessary, a point which emerges from this book, particularly from the chapter by Dr. Erwin Reifler on "The mechanical determination of meaning".

It can now, I think, be said that, given sufficient effort, a translating aid based on the use of a data-processing machine could be developed which would provide translations acceptable to scientists and technicians. Whether there would be any commercial future for such a scheme would depend largely on the cost of operating it. Large data-processing machines are expensive but they are very versatile, and it would not be necessary for the machine to be used exclusively for translating. It would, however, be desirable to use a machine which had been designed with the translating problem specially in mind. On the whole, I do not think that cost would prove an insuperable barrier if the scheme were otherwise attractive.

THE ECONOMICS OF SCIENTIFIC PUBLICATIONS

One of the indispensable functions of scientific and technical societies is the publication of journals. Today, however, many societies find that this kind of publication can absorb something like 30% of their total annual income, and some have reached the stage of being unable to meet this expense without some form of subsidy. The Nuffield Foundation is now studying the best way of assisting the learned journals, and £43,750 has been allocated for the purpose for a period of five years. Initially preference will be shown to the humanities rather than science. The British Academy and the Royal Society have been informed that a sum of £8000 a year will be available over the next five years, to be spent on the support of primary journals in primary subjects. Details of the individual grants to science journals will be decided by a committee appointed by the Foundation in consultation with the Royal Society.

The Nuffield Foundation says that the only hope for narrowing the gap between costs and returns for learned journals generally seems to lie in improving production and sales techniques and in some measure of centralisation of effort. In order to collect the necessary information about these matters Mr. Robert Lusty, vice-chairman of the publishing firm of Michael Joseph Ltd., is carrying out a pilot survey of the publishing and distribution practices of the learned journals on behalf of the Foundation.

FAR AND NEAR

The Night Sky in February

The constellation Auriga—the Charioteer—is conspicuous during this month, and those who are conversant with the chief stars in Ursa Major (or more especially with the seven brightest stars in it, which are known as the Plough) can find Capella, the brightest star in Auriga, as follows. Draw an imaginary line from the fourth to the first of the stars in the Plough—otherwise known as Delta and Alpha Ursae Majoris—and produce it five times the distance between these two stars; the line will pass very close to Capella. At the beginning, middle and end of February, it will *seem to be* nearly overhead at 10.30, 9.30 and 8.30 p.m. in Great Britain, but these figures are more correct for places in the south and not so accurate for those far north. This star is more than 40 light-years from us and has a diameter about twelve times that of the Sun. The spectroscope has shown that it is a very close double star, the period of revolution of its companion round Capella (more precisely, round the centre of gravity of the system) being about 100 days. A little east of Capella you will see Beta Aurigae which is not quite as bright as Capella and is also a double star.

During the month *Venus* sets at 6.25 p.m. on February 1 and towards the middle of the month is best seen in the morning hours, rising at 6.50 and 6 a.m. about the middle and end of February. *Mars* rises about 5 a.m. throughout the month, and lies rather low for good observation. *Jupiter* is visible throughout the night in the constellation Leo and in the early part of the month is close to Regulus, the brightest star in Leo. *Saturn* rises in the early morning hours and lies rather low in Scorpius.

Science and the New Year's Honours

Knighthoods have been conferred in the New Year's Honours List on Dr. Eric Ashby and Prof. Solly Zuckerman.

Dr. Ashby, who has been vice-chancellor of Queen's University, Belfast, since 1950 still finds time to do research in the field of plant physiology. After a number of years on the staff of the Imperial College of Science and Technology, London, he went to Australia in 1938 and occupied the Chair of botany at Sydney from then until 1946. During the war he conducted an inquiry for the Australian Prime Minister into the mobilisation of scientists, and in 1945–6 he served in Russia as scientific counsellor with the Australian legation in Moscow. His Russian experiences provided the basis for his well-known book, *Scientist in Russia*. He spent the next four years as Harrison Professor of Botany at Manchester.

Prof. Solly Zuckerman, who was born in Cape Town, wields considerable influence through his long association with the Lord President's Advisory Council on Scientific Policy. He is, for example, chairman of the Council's committee on scientific manpower, which recently reported on Britain's needs for graduate engineers (see Discovery, January, 1956, p. 42). A zoologist by profession, he is an authority on the primates about which he has written two books—*The Social Life of Monkeys and Apes* (1932) and *Functional Affinities of Man, Monkeys and Apes* (1933). He has held a succession of academic posts, beginning with a demonstratorship at Cape Town. He has been Sands Cox Professor of Anatomy at Birmingham since 1943. During the war he became one of the great exponents of operational research techniques, and his ideas were used by the RAF in planning the tactics of aerial bombardment. He is married to a daughter of the 2nd Marquess of Reading.

Another knight is Dr. Eric James, one of the few science masters to be appointed to an important headship. He has been High Master of Manchester Grammar School since 1945. In August 1952 we printed a powerful article by him entitled "Science in the Schools". To meet the critical situation with regard to science teaching, he made a number of valuable suggestions, a number of which have since been implemented by the authorities. One suggestion was that science teaching should be regarded as an alternative form of National Service, and this idea was eventually adopted by the Government and brought into force as recently as last month.

Prof. A. G. Pugsley, who has been Professor of Civil Engineering at Bristol since 1945, also received a knighthood. He is an aeronautical expert, and spent fourteen years on the staff of the Royal Aircraft Establishment.

Dr. Kathleen Lonsdale, the well-known x-ray crystallographer, becomes a Dame of the British Empire. She holds a professorship at University College, London.

Atomic News

The General Assembly of the United Nations has given final approval to the setting up of an international atomic energy agency as soon as possible. It has also approved the proposal that another international conference on atomic energy like the one held in Geneva last year should be held within two or three years.

Britain's Atomic Energy Authority has concluded an agreement with the Indian Department of Atomic Energy which ensures that there shall be close co-operation and mutual assistance between the AEA and the Department in the promotion and development of the peaceful uses of atomic energy. The AEA will be providing India with enriched uranium fuel elements for a "swimming pool" reactor now under construction at Bombay. The agreement also includes arrangements for the Authority to assist in the design and construction of a high flux research reactor which may be built at a later date.

Australia's "Harwell" will be built on a site at Lucas Heights, south of Sydney. It will cost £A5½ million, and is due to be completed by June 1957. Its research reactor will begin building this April. Part of its work will be the testing of materials for the construction of atomic power generators. Emphasis will be on generators producing from 5000 to 10,000 kilowatts, much needed for the development of inland Australia.

White Paper on Technical Education

The Government is publishing its long-awaited plan for the expansion of technical education in a White Paper due out this month. This news was given in the Prime Minister's speech at Bradford on January 18th.

Electronic Computer for Met. Office

The Meteorological Office is to acquire a digital electronic computer for installation in the Napier Shaw Laboratory at Dunstable. This is needed for a much expanded programme of research into numerical methods of weather forecasting based on hydrodynamical principles, and the computer will also be available for other complicated problems of meteorology where very heavy numerical work is involved.

Index of University Theses

ASLIB has just published Volume II of the *Index to theses accepted for*

PROF. SOLLY ZUCKERMAN

higher degrees in the universities of Great Britain and Ireland, covering the academic year 1951–2. Arranged under subject headings, this volume lists over 3000 thesis titles, and gives the authors' names and universities and the degree for which it was presented. Volume I (1950–1) of the *Index* has been reprinted and copies are now available. The price of each volume is 25*s*. (or 21*s*. to members of ASLIB).

Centenary of "The Engineer"

Last month *The Engineer* celebrated the centenary of its first appearance (on January 4, 1856) with the issue of an impressive Centenary Number. This contained a history of *The Engineer*, four pages of reproductions of engravings from old issues, a series of twenty-six articles contributed by eminent engineers under the general heading "Influences on Engineering Advancement 1856–1956", and a list of manufacturing firms, societies and journals that are over 100 years old.

Only four technical journals within the field of engineering and allied industries are older than *The Engineer*. The oldest is *Mechanics* founded in 1823 as *Mechanic's Magazine*.

The editorship of *The Engineer* has remained in the same family for ninety years. The present editor is Benjamin Pendred, who succeeded his father, Loughnan Pendred in 1946. His grandfather, Vaughan Pendred, edited the journal from 1865 to 1905.

The New Astronomer Royal

DR. RICHARD VAN DER RIET WOOLLEY arrived in England on January 2 to take up his appointment as Astronomer Royal in succession to SIR HAROLD SPENCER JONES. He put the cat among the astronautical pigeons within a few minutes of his arrival at London Airport by telling pressmen that he regarded the prospect of interplanetary travel as "utter bilge". He added: "I don't think anybody will ever put up enough money to do such a thing. It would be enormously expensive, but if the next war could be won by the first chap getting to the moon and by that alone, some nation might put up the enormous amount required. I cannot give any idea how much it would cost, but it would be a very large sum indeed. It is all rather rot. I don't think anybody will go anywhere in the ordinary way."

Asked about the future of the Royal Observatory he said: "There was a time, about 100 years ago, when the English were pre-eminent among the world's astronomers not only for theoretical work but for observing. There has been a tendency of late for this headquarters to be in California, but we hope to make some attempt to get England back to the fore in scientific astronomy and astro-physics. There is a new telescope, the Isaac Newton memorial telescope, with a diameter of 90 inches. What we are interested in is the question of stars in relation to nuclear physics, and the interior of the stars. We have much work to do." He considered that the Commonwealth has one advantage over the U.S.A. in having the two largest telescopes in the southern hemisphere—one in Australia and the other in S. Africa.

Science Masters' Conference

A number of experiments with radioactive isotopes suitable for schools were demonstrated at the annual meeting of the Science Masters' Association, held in London on December 28–30. The demonstrations were arranged by members of the Association's Radioactivity Sub-committee, whose chairman (Mr. W. G. Rhodes of Firth Park Grammar School, Sheffield) told the meeting that radio-isotopes are now so widely used in industry and in the applied science and medical departments of the universities, and were such an integral part of civil defence training "that it has become imperative that we should give our students some opportunity of seeing and carrying out experiments with radioactive isotopes".

"Science and Education" was the theme of the presidential address by Sir Edward Salisbury, director of the Royal Botanic Gardens, Kew. He urged the importance of the ecological approach, saying that "the study of the environment of necessity invokes the integration of many branches of knowledge, and thus evokes an ideological pattern in which a diversity of disciplines find their places as part of a coherent whole".

Sir Edward said that the marriage of science and the humanities is essential to the success of the civilisation of the future. "It would be fatal both practically and intellectually if there were to develop a dual culture of the arts on the one hand and the sciences on the other. The vast advances that have been made in the past two decades in such fields as electronics and atomic energy, each with its own technical language and complicated techniques, could easily lead to such a divorce. Such can only be averted by a deliberate effort to ensure that the generality of at least the more educated of the non-scientific population comprehend what the scientist has achieved and what he is aiming to accomplish. An achievement, however, which demands that the scientist should be able to write good English and that the humanist should be prepared to take the trouble to understand him. One may therefore suggest that the art of good expression is of equal importance to those who dedicate themselves to science as to those who pursue the study of the arts. To both alike accuracy and aptness in the spoken and the written word is essential and not least for the intercourse between discipline and discipline. It should be the especial privilege of science to inculcate the virtues of exact observation and its concomitant exact expression."

Sir Edward reminded his audience of the remark that the Duke of Edinburgh made at his installation as vice-chancellor of Edinburgh University: "The sympathetic attitude of mind between the arts and sciences must be established at school, for to leave this to be accomplished at the University is too late." The whole community must be brought to realise, he said, that the function of a science master is not that of a mere purveyor of useful information still less a gadgetmonger, but an essential participant in laying the foundations on which a fruitful life and useful citizenship can alone be built.

Antibiotic for Treating Ringworm

Two American women doctors, Dr. Elizabeth L. Hazen and Dr. Rachel Brown, of the New York State Department of Health's Division of Laboratories and Research in Albany, have been awarded the first $5000 Squibb Award in chemotherapy for the discovery of a new anti-fungal drug, nystatin. This is the first anti-fungal antibiotic considered safe for use on human patients. The drug is now being used in the treatment of athlete's foot, ringworm and fungal infections of the mouth.

Personal Notes

DR. R. S. MILLARD has been appointed the Head of the newly formed Colonial Section of the Road Research Laboratory, Harmondsworth, with the rank of Deputy Chief Scientific Officer.

I.C.I. Ltd. announces the appointment of two Assistant Publicity Controllers under MR. B. W. GALVIN WRIGHT. They are MR. GORDON LONG and MR. A. Q. TOLLIT. Mr. Long will continue to be responsible for the Publicity and Information Sections of the Central Publicity Department, including the Press Section headed by Mr. Geoffrey Richards. Mr. Toliit will be responsible for the Commercial Advertising Section of the Department, which will allow Mr. W. J. Marrable to concentrate upon the company's expanding exhibitions programme.

General Electric Research Laboratory of Schenectady has established a European office and appointed DR. GEORGE J. SZASZ as its first scientific representative abroad. For the present, Dr. Szasz will maintain an office with the International General Electric Ltd., Crown House, Aldwych, London, W.C.2.

Royal Society Obituaries

A valuable source of biographical information has been the *Obituary Notices of Fellows of the Royal Society*, of which nine volumes were published between 1932 and 1954. The title of this serial publication has now

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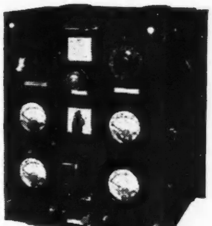

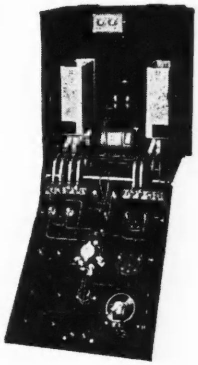

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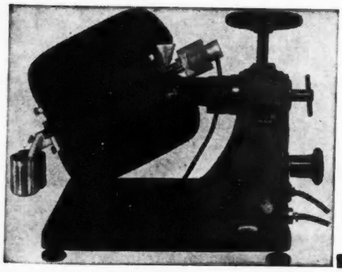

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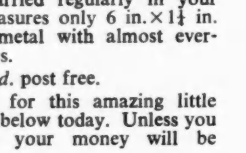

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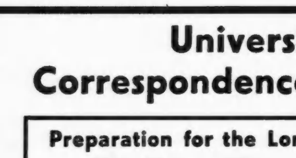

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MINISTRY OF LABOUR AND NATIONAL SERVICE: H.M. INSPECTORS OF FACTORIES (CLASS II). The Civil Service Commissioners invite applications from men and women for pensionable posts. Age at least 21 and (unless exceptionally well qualified) under 30 on June 1 in the year of application with extension for regular service in H.M. Forces. London salary (including extra duty allowance where payable) £506 (at age 21), then according to age up to £669 at 26 or over, rising to £917. Somewhat lower outside London. A special increment of £25, within the scale, is granted after passing probation. Higher posts filled by promotion from Class II.

Duties include the enforcement of the provisions of the Factories Acts and Regulations affecting the safety, health and welfare of workpeople and extend to all manufacturing industries and to certain other places, including Docks, Works of Engineering Construction and Building Operations.

Candidates must normally be university graduates, preferably in Engineering or Natural Science (or comparable technical qualification, e.g. A.M.I.Mech.E.). Graduates in other subjects, including Arts, are eligible. Works or other practical experience an advantage. Candidates without degrees (or comparable technical qualifications) who have good general or technical qualifications, and have had considerable works or other practical experience (especially in responsible positions) will also be considered.

Application may be made at any time, and so long as there are vacancies suitable candidates will be interviewed.

Particulars from Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 280.

SPECIALIST ASSISTANT required by the GOVERNMENT OF NORTHERN REGION NIGERIA Agricultural Department for one tour of 12/24 months in first instance either (*a*) with prospect of pensionable employment—salary scale (including inducement addition) £750 rising to £1554 a year—or (*b*) on temporary terms—salary scale (including inducement addition) £810 rising to £1716 a year plus gratuity at rate of £100/£150 a year. Commencing salary according to experience. Outfit allowance £60. Free passages for officer and wife. Assistance towards cost of children's passages and grant up to £288 annually for maintenance in U.K. Liberal leave on full salary. Candidates, preferably under 35 years of age, must be highly trained in laboratory techniques of either Plant Pathology or Entomology and should possess a Diploma of the Science Technologists Association or similar qualification or experience. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M3A/35303/DI.

Applications are invited for pensionable posts as

ASSISTANT EXAMINERS in the PATENT OFFICE

to undertake the official scientific technical and legal work in connexion with Patent Applications. There are a small number of similar posts in the Ministry of Supply. Applications may be accepted up to December 31, 1956, but early application is advised as an earlier closing date may be announced. Interview Boards will sit at frequent intervals.

Candidates must be between 21 and 28 years of age during 1956 (up to 31 for permanent members of the Experimental Officer Class) and have First or Second Class Honours degree in physics, chemistry, mechanical or electrical engineering, or mathematics. Candidates taking their degrees in 1956 may apply before the result of their degree examination is known.

Starting emoluments in London, including Extra Duty Allowance for 45½-hour week, between £554 and £794 (men), £712 (women), according to periods of National Service and post-graduate experience, rising to £939 (men) and £869 (women). Promotion to Examiners—£977 to £1344 (men), £896 to £1247 (women); normally after 5 years (3 or 4 years in exceptional cases). Women's scales subject to increase under equal pay scheme. Good expectation of promotion to Senior Examiner (£1344 to £1620 men) with reasonable expectation of further promotion to Principal Examiner (£1620 to £1850 men). Candidates are recruited by selective interview.

Application forms and further information from the Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting number S 128/56.

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APPLICATIONS invited for post of a Chief Engineer in India, for Nangal Fertilizer-Heavy Water Project, on a salary up to £2700, for an exceptionally qualified candidate.

Applicant must have training in the design of chemical plant and about ten years' experience in the erection and maintenance of industrial plants, preferably for the manufacture of ammonia and fertilizers. Age preferably above 45.

Initial appointment is on contract but may be made permanent.

Supplementary information and forms of application from High Commission of India, Establishment Department, Aldwych, London, W.C.2, quoting 202/9/21A. Last date for receipt of applications February 29, 1956.

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GRANTS & SCHOLARSHIPS

THE NUFFIELD FOUNDATION

SOCIOLOGICAL SCHOLARSHIPS AND BURSARIES.

The Nuffield Foundation, in pursuance of its programme for the advancement of sociological studies, is prepared to offer for the academic year 1956–7 a small number of scholarships and bursaries to enable graduates in academic subjects other than the social sciences, psychology or economics, to study the social sciences. The Foundation's particular object is to enable men or women, who are already well qualified in other disciplines, particularly the natural sciences or the humanities, to

receive a training in, for example, political science, social psychology, anthropology, social statistics and sociology generally (but not economics) so that in due course they may undertake research or teaching in the United Kingdom in those subjects. *The scholarships,* which are the senior awards, are intended for persons who have already undertaken some post-graduate work in their own subject. *The bursaries* are intended to enable those who have recently graduated to take a course of training in sociological subjects. In the case of both scholars and bursars the Foundation will pay the cost of university and/or college fees in addition to a maintenance award. Graduates of Universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35, are eligible to apply.

Applications for awards in 1956 must be received before May 1, 1956, by the Director, The Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1, from whom full particulars and application forms can be obtained.

L. FARRER-BROWN,
Director of the Nuffield Foundation.

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Biological Scholarships and Bursaries

The Nuffield Foundation, as part of its programme for the advancement of biological studies, is prepared to offer for the academic year 1956–7 a limited number of scholarships and bursaries to enable persons who have graduated in physics, chemistry, mathematics or engineering, but who have had no training in a biological subject, to receive such training in biology as will enable them in due course to undertake research and teaching in the United Kingdom in the biological sciences. *The scholarships,* which are senior awards, are intended for persons who have already undertaken some post-graduate research in their own subject. *The bursaries* are intended to enable those who have recently graduated to complete a course of training in biological subjects including, if considered necessary, a full honours degree course in biology. In the case of both scholars and bursars the Foundation will pay the cost of university and/or college fees in addition to a maintenance award. Graduates of Universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35, are eligible to apply.

Applications for awards in 1956 must be received before April 1, 1956, by the Director, The Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1, from whom full particulars and application forms can be obtained.

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FAR AND NEAR—continued

been changed to *Biographical Memoirs of Fellows of the Royal Society.* The first volume with the new title appeared just before Christmas, and includes notices on Einstein (by Sir Edmund Whittaker) and Fermi (by E. Britscher and Sir John Cockcroft). It costs 30 shillings, and can be purchased from any bookseller or direct from the Royal Society.

Boron by the Ton

Borox Consolidated Ltd., of Carlisle Place, London, S.W.1, is now offering *amorphous* elemental boron from pilot-scale production. Two grades are available, one of 90–92% and the other 95–97% purity, by the pound or by the ton.

SIMA Starts Instrument Centre

A permanent exhibition by member firms is to be opened by the Scientific Instrument Manufacturers' Association at their headquarters at 20 Queen Anne Street, London, W.1, on February 9. The exhibition will be open to anyone interested in using any of the wide variety of instruments manufactured by SIMA members. Overseas visitors especially should find the show useful, since they will be able to inspect there equipment made by firms from all parts of the country. A comprehensive library of manufacturers' catalogues is also being established.

Careers in Plastics and Radio Engineering

The Plastics Institute (The Adelphi, Adam Street, London, W.C.2) is issuing a revised version of its brochure *Careers in Plastics.*

The Plastics Industry Education Fund (which is connected with the Plastics Institute) announces that it has made grants to students totalling £3500 up to the end of November 1955. Any inquiries about the aid it provides to students should be sent to the Fund's secretary.

Engineers in the B.B.C. is another careers booklet, and can be obtained from the Engineering Establishment Officer, B.B.C., London, W.1.

A Miniature Planetarium Invented in Poland

In the Polish scientific monthly *Problemy,* No. 8, vol. II, August 1955, p. 560, a Wroclaw engineer, Leonard Weber, describes a miniature planetarium he has constructed. It is portable, being no larger than an average brief case. The cost of producing it is remarkably low, and when the apparatus is put into mass production it will be possible to introduce it into every school. The Ministry of Education in Poland has recently approved this planetarium for school use as a teaching aid in geography and astronomy.

Printed and published in Great Britain by Jarrold & Sons Ltd., Norwich *Editorial Office: 244 High Holborn, W.C.1*

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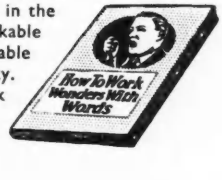

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The Nobel Division of Imperial Chemical Industries Ltd. is an important supplier of the specialised explosives and detonators used in 'Seismic Prospecting', as the technique is called, and their prospecting explosives have won an enviable reputation for reliability in the far-off tropical and desert lands where oil is found.

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